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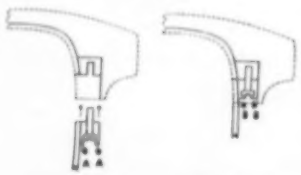

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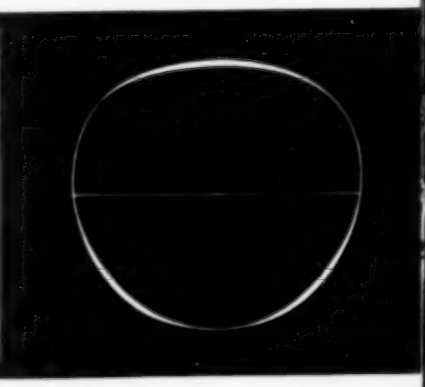

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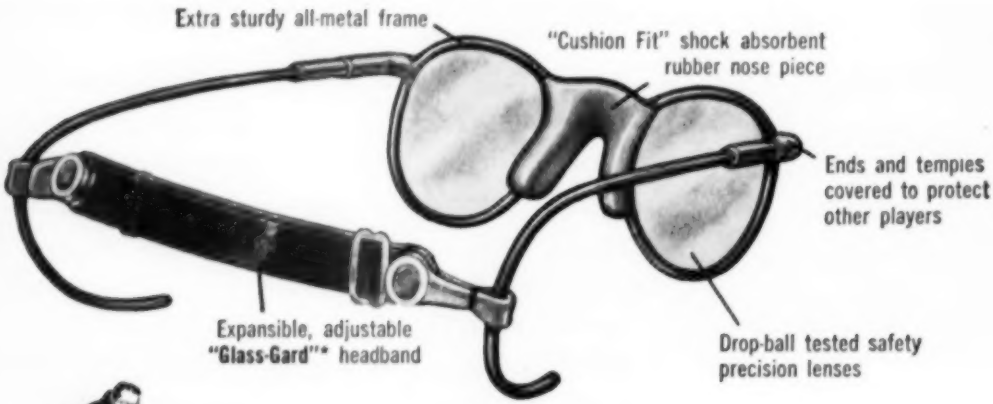
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VISUAL ACUITY — AN ANALYSIS OF THE STIMULUS SITUATION*

Frank W. Weymouth†
Los Angeles College of Optometry
Los Angeles, California

The year 1954 is an appropriate year for the consideration of visual acuity. In 1864 Donders published the Anomalies of Accommodation and Refraction of the Eye. In 1862, at Donders' suggestion, Snellen developed the test types bearing his name. Over the decade 1856-1866 Helmholtz published the three volumes of Physiological Optics. Thus 1954 may justly be considered the ninetieth anniversary of that understanding of the eye and its refraction that gives meaning to visual acuity.

What is visual acuity? Operationally, visual acuity is the result obtained from a certain type of test, but as there are many tests, many results having different meanings are possible. Tests and testing have been studied throughout the past ninety years. Still vigorously growing, this knowledge springs from diverse and often unexpected sources, appearing not only in journals of optometry and ophthalmology but in journals of astronomy, biology, physiology, psychology and other less obvious fields. The specialization and compartmentalization of modern science is nowhere more striking and pernicious than in the study of the eye. A detailed study of one aspect, carried out in ignorance of others, may, in consequence, be fundamentally misinterpreted. A plethora of details varying widely in nature and significance calls for synthesis and evaluation.

Our visual percepts, including those of visual acuity, rest on two transformations. The external pattern of luminances is optically transformed into an internal stimulus pattern, which, in turn, by retinal stimulation and alteration of cortical activity, is transformed into a visual percept. Certain aspects of these transformations, comprising a large part of physiological optics, are basic to an understanding of visual acuity.

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†Ph.D. Member of faculty. Fellow, American Academy of Optometry.

The external stimulus pattern can be controlled and accurately measured, and the percepts, or the reactions corresponding to them, can be classified and described. But the middle term, the internal stimulus pattern and its stimulation of the retina, is not as accessible. Its study is beset with peculiar difficulties. The retinal image may be observed but only in a general way in contrast to the detail furnished by the analysis with a microphotometer of a photograph of an image formed by a glass lens. But detail is exactly what is needed. The retina upon which the image falls is an extraordinarily complex and compressed receptive field. In an area of about 10.5 mm.^{2} (1.6 sq. in.) there are crowded some 129,000,000 rods and cones, a number roughly equal to the population of the United States in 1935. On the other hand, the retina is one of the tissues most sensitive to oxygen lack, operative violence, or any of the vicissitudes of experimentation. In consequence the information most needed is hard to get.

TYPES OF VISUAL ACUITY TESTS

As stated above there are many tests of visual acuity. A recent comparative study considered 14: a search of the journals might double the number. Different test objects suffer in various ways from their optical transformation and present differing sensory problems. On optical and physiological bases three types may be distinguished.

A. *Threshold for point or line.* The threshold for a point or line has been used as a test of visual acuity. Although differing from common reading material it has been considered by some workers as a good indication of the competence of the eye in more usual tasks. It represents the simplest perceptual task, to report whether or not an object is present in the field.

B. *Vernier.* Visual acuity may be measured by the smallest recognizable relative displacement of two segments of a line: this is involved, for example, in the setting of lines on a slide rule, and less clearly in some tests under the name of "form." It is not a test in common use. The optical problem differs markedly from either of the other types: the retinal problem is that of position or *localization.* Perceptually it is more complex than the threshold, showing marked field effects related to the length of the line segments and the like.

C. *Resolution.* The line, or other element, may be combined to give various figures including

1. the *grid* of parallel lines or
2. *letters.*

These test objects present problems of optical imagery and retinal analysis different from those of the isolated line. The grid (or the

related checkerboard) presents an optical task of resolution with a perceptual problem of moderate difficulty. Letters present the most complex perceptual situation of any type of test, a complexity seldom fully realized.

It will not be possible to consider all types of acuity tests. The line will be taken as a form which may be used alone or which may enter into more complex test objects. Certain of the optical and sensory problems involved in the use of the line will be analyzed in detail.

STIMULATION SITUATION

It may be well here to state in more detail the *stimulation situation*. The stimulation situation involves the total external stimulus pattern, the internal stimulus pattern into which the external pattern is transformed and the reactive capacity of the retina as affected by its inherent regional differences, by the state of adaptation or the effect of previous stimulation, as well as previous visual experience.

The first element of the stimulus pattern is the *adapting field*. Because of the huge range of retinal sensitivity, it is necessary to report, for each observation, the level to which the eye has been adapted. Adaptation requires that the retina is exposed, and for an adequate time has been exposed, to an adapting field of known luminance which covers so large a portion of the visual field as to dominate it. Some have considered a field of 16° satisfactory but larger fields up to 30° appear to give more stable results.

Against this adapting field some relatively small part, the *test area*, or figure (here a line), must present a luminance differing from the field. The test area-field pattern is characterized by three features: (a) the *time* during which the test area differs from the ground, (b) the *difference in luminance*, or *contrast*, between the test area and the field, and (c) the *visual angle* of the test area. The task of the observer is usually to report whether the test area differs in brightness from the ground, i.e., whether the total field is, or is not, homogeneous. Visual acuity sets a more difficult task than this, such as the orientation of the line or identification of the letter. Changes in any of these elements, in the critical region near the threshold, may determine whether a sensation is produced or not, and a decrease in one factor may be compensated for by an increase in another.

The external stimulus pattern, projected in a modified form by the image forming apparatus of the eye upon the retina, becomes the *internal stimulus pattern*. The relation between the external and

internal patterns is crucial to the analysis of the stimulus situation. The three aspects listed above will be considered separately.

The *time relations* of the external stimulus are accurately represented on the retina. Retinal stimulation and other processes, however, are time consuming so that vision is, compared with hearing, for example, a sluggish sense.

The absolute luminance of the retinal image, perhaps one-twentieth of the stimulus luminance, is not here our main interest. The ratio of the luminance of the central part of a large test area to the luminance of the field, the contrast, is duplicated in the image, and this is a matter of importance. It is otherwise, however, with the figure-ground margin of the image and this must be considered in detail. It is a commonplace that the sharp transition in luminance at the margin in the object is blurred in the retinal image to give what has been called an "edge gradient" by Cox[1] and Shack.[2] The edge gradient (the term should be restricted to small degrees of blurring in a well focused system) has been proposed as a criterion for the evaluation of lens performance and it may serve equally well for the eye. A careful determination of physical light intensity as a function of distance on the plate or retina is obviously necessary for its use as a criterion. The density in a photograph made with a camera lens gives a sigmoid curve symmetrical about the edge of the geometric image which agrees well with the summation of the calculated values of the common aberrations and diffraction, and which Schade[3] claims is closely approximated by the $\cos^2$ function of the radius of a circular stop. It is probable that the edge gradient of the retinal image is similar although this requires empirical confirmation which is still lacking. The results of subjective stigmatoscopy[4] are suggestive and emphasize features peculiar to the eye such as the "star" effect and the great range of individual variation, but do not furnish the basis for calculating the shape of the edge gradient. The exact form of the gradient fortunately does not affect the qualitative aspects of the argument here presented, but is important for the quantitative results such as the critical width of a line discussed below. It should be pointed out in passing that the purpose of fitting glasses, not always recognized, is by the reduction of focal errors to make maximal the slope of the edge gradient.

The role of the third element, the *visual angle* of the test area, must be approached indirectly. To repeat, the image of a relatively wide line is bounded by gradients, changes in light intensity with retinal position, which have a sigmoid form. The central portion of the image bears, as stated, a ratio to the ground which is the same as that in the

object. But as the line is made narrower the situation changes markedly. The two edge gradients finally meet in the center and then overlap with the result that the intensity of the middle of the line falls below that of the wider line and hence the ratio to the ground intensity also falls. At the same time the edge gradient becomes less steep. The process is shown in Figure 1. The detail of the form of the edge gradient

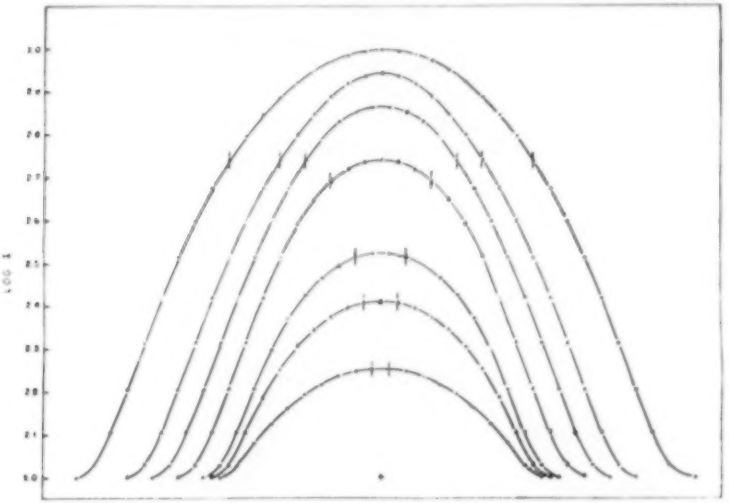

Fig. 1. Comparison of the geometrical and the physical images on a dark ground, of a bright line at and below the critical width; abscissa, width in arbitrary units, ordinates, log intensity. The continuous curve represents the physical image, the short vertical lines cutting each curve represent the width of the corresponding geometrical images. Curve 1 (upper) represents the situation at the critical angular width at which the edge gradients first meet; in the other curves the geometrical images present the following percentages of that at the critical width. 2 = 66.7, 3 = 50, 4 = 33.3, 5 = 16.7, 6 = 11.1, 7 = 5.6. The difference in log intensity between the ground and the line is arbitrary but is of the magnitude of an observed threshold. The physical intensitites are summations of the overlapping edge gradients based on the $\cos^2$ function suggested by Schade.[2]

has little effect on the qualitative aspect of image formation but is critical to the quantitative aspect, affecting the critical angular width and the exact relation of image to object size below the critical width. Below the critical angular width at which the edge gradients meet, a test line of constant contrast but decreasing width will produce an image in which the changes are markedly different. Depending in part on the width of the line, the following changes occur (cf. Figure 1). (a) The width of the image decreases, (b) more strikingly, the contrast between the center of the image and the ground decreases, and

(c) the edge gradient becomes less steep. The changes, particularly those in contrast, soon cause the line to fall below the threshold and disappear. If the contrast in the stimulus pattern is low or moderate, the image may again be brought above the threshold by increasing the contrast in the stimulus, since this will increase the contrast between the center of the image and the ground and steepen the edge gradients without materially affecting the width of the image.

The critical angular width for the line is not accurately known. It is, for example, affected by the length of the line, the level of adaptation, and individual variations in the edge gradient. For the short line (twice as long as wide) used by Hendley,[5] the threshold contrast

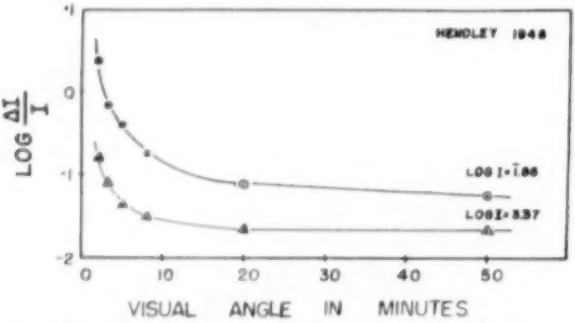

Fig. 2. Threshold values of log $\Delta I/I$ as a function of the visual angle at two levels of luminance. Data from Hendley.[5]

becomes asymptotic at about 20 minutes (Figure 2). For longer lines the critical width is placed by Fry[6] at about 4 minutes, by Bryam[7] between 2 and 5 minutes and a width of about 2 minutes is suggested by the data of Hartridge.[8]

To recapitulate, the relations between the three factors are as follows. The *time* relations of the internal pattern parallel those of the external. Above the critical size, the width of the physical image is equal to that of the geometric image with the addition of a factor depending on the edge gradient. In this case the central part of the image shows the same percentage contrast to the ground as does the external stimulus pattern. For the small range below the critical angular width and above the threshold the relations are more complex. Here the line-image width differs from the geometric image by a factor that varies with the width of the line. In this range the slope of the edge gradient and the contrast between the center of the image and the ground become less as the line is made narrower. Thus the width of the object-line affects both the width and the contrast of the image.

The stimulus situation, mentioned above, is one in which the particular combination of time, contrast and visual angle produces a sensation in half the trials. Clearly there are many such combinations. In general if one factor is reduced, bringing the combination below the threshold, increases in either or both of the others will bring it again above threshold. This is because the relation of each factor to the sensation is positive, an increase in time, a higher degree of contrast, or a greater visual angle tending to produce stimulation, the relation between factors being reciprocal in type. This relation is neither simple nor completely known, but it may help to visualize the stimulus situation if the three factors are thought of as plotted along three mutually perpendicular axes. The stimulus situation or locus of minimum effective combinations will then be a surface of hyperboloid form approaching each axis asymptotically.

A similar attitude toward the stimulus situation, although this term is not used, is stated by Hurvich and Jameson in their careful psychophysical study of white:[9]

> "It is . . . clear . . . that white cannot be defined psychophysically as a unique response to any single physical stimulus or to a narrowly restricted range of physical stimuli. Even for a neutral state of adaptation, a single exposure time and single test area, white must be defined psychophysically as a function of at least two stimulus variables, color temperature and luminance."

This situation is well illustrated by the various threshold combinations of their experimental findings.

While on the subject of the stimulus situation, a comment regarding certain traditional terms may not be out of place. *Minimum visible, minimum separable, minimum legible* or *minimum cognoscible* are terms inherited from a period in which the relations involved in the stimulus situation were not realized. "Minimum visible" implies that the size of the dot is the only variable to be considered. "How small a dot can be seen?" has no answer, since time, contrast and the level of adaptation are not given. It is time all these terms were relegated to the limbo of the historical museum.

QUANTAL STIMULATION

The quantal aspect of retinal physiology must be considered. Since Hecht and his students[10] first stated the absolute threshold of the eye in quanta, work in this field has made it increasingly clear that the action of light on the retina is quantal. Bouman[11] may be cited as typical of current attitudes. The recent paper of Wald,[12] based in part on the microhistological studies of Sjöstrand,[13] which presents a definite hypothesis of the quantal stimulation of rods and cones may be said to have closed the period of mass action chemical explanations in retinal

physiology. The hypothesis may require extensive modification but it will remain quantal. This development is reasonable. Modern physics regards the interaction of light with matter as quantal, in contrast to wave transmission with minimum absorption in transparent media. This approach appears particularly necessary in structures as small as the external segment of a foveal cone, the diameter of which is only two or three times the wave length of visible light in this medium.

If the stimulus situation regarding the three factors of time, contrast, and visual angle is considered from the quantal viewpoint, it reduces to gradients in quantal density in time and space. The reciprocal type of relation noted earlier obviously means that a number of combinations may deliver the critical quantal density gradients and thus produce stimulation.

COMPARISON OF DIFFERENTIAL LIGHT SENSITIVITY AND VISUAL ACUITY

Thus far the threshold in terms of the available external stimulus pattern has been described in general terms. The factors of the stimulus must be more closely examined in their relation to two types of test, the differential light threshold and visual acuity. The differential threshold has been traditionally measured using constant time and visual angle, the only variables then being the contrast and the level of adaptation. The commonest symbol for the adapting field is I and for the difference of the test object from the field, ΔI. Influenced by Weber's law, according to which the recognizable difference approximates a constant ratio to the acting intensity, the contrast is more often represented by $\Delta I/I$. Because of the huge range of luminance involved all values are commonly expressed as logs, and this custom will be followed throughout the following discussion.

The threshold contrast for different levels of adaptation may thus be presented in two ways, (a) log ΔI as a function of log I, or (b) log $\Delta I/I$ as a function of log I. For comparison with visual acuity the data may be presented as differential light sensitivity by plotting the reciprocal of log $\Delta I/I$, (c) log $I/\Delta I$ as a function of log I. Data from Mueller,[14] Graham and Kemp[15] and Hendley[5] are presented in these three ways in Figures 3, 4 and 5. These graphs show the general type of relation between these different expressions and indicate a common source of confusion. Depending on which picture a person has in mind he may say, or write, if the other factors are held constant, that the threshold contrast rises or that it falls with increase in the general illuminance. No comment of this type is correct unless contrast is defined and it is clear whether threshold or sensitivity is being considered.

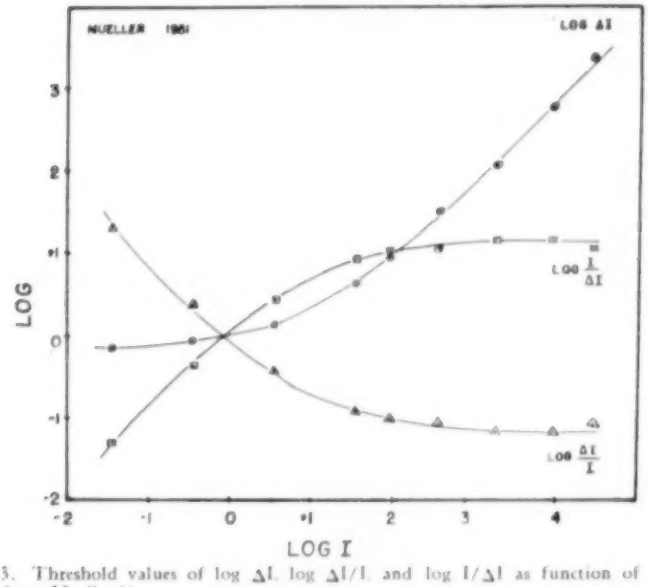

Fig. 5. Threshold values of log ΔI, log $\Delta I/I$, and log $I/\Delta I$ as function of log I. Data from Mueller.[14]

For a satisfactory comparison of visual acuity and differential light sensitivity, data from the same observers should be obtained at the same time. A short line or a Landolt C might be used and a series of stimulus situations in terms of time, contrast and visual angle determined, the task for differential sensitivity being presence or absence; for visual acuity, orientation. Since the task for visual acuity is the more difficult it might be expected that it would require a higher level for the combined factors. Since such data are not available, the findings of Mueller[14] (log $I/\Delta I$ as a function of log I), and of McFarland[16] (log visual acuity as a function of log I) are presented for comparison in Figure 6. It will be seen that the curves are similar in shape. The ordinate scales are different (log contrast and log 1/visual angle); a suitable choice of scales will satisfactorily superpose the curves. Obviously this does not prove their identity; agreement of curves as an argument is permissive but not compulsive. It does, however, suggest that further exploration would be justified.

The comparison of visual acuity with differential light sensitivity may be facilitated by the use, as just suggested, of the same test figure, thus simplifying the optical situation, while the perceptual tasks are

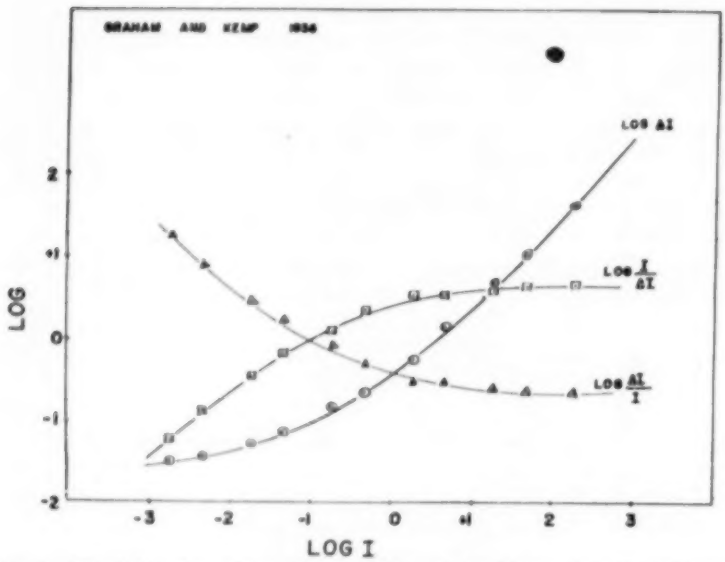

Fig. 4. Threshold values of log ΔI, log $\Delta I/I$, and log $I/\Delta I$ as functions of log I. Data from Graham and Kemp.[15]

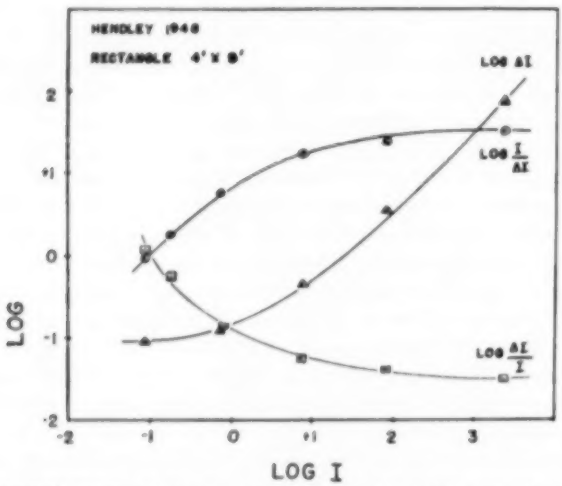

Fig. 5. Threshold values of log ΔI, log $\Delta I/I$, and log $I/\Delta I$ as functions of log I, for a rectangular test object 4 by 8 minutes in angular subtense. Data from Hendley.[5]

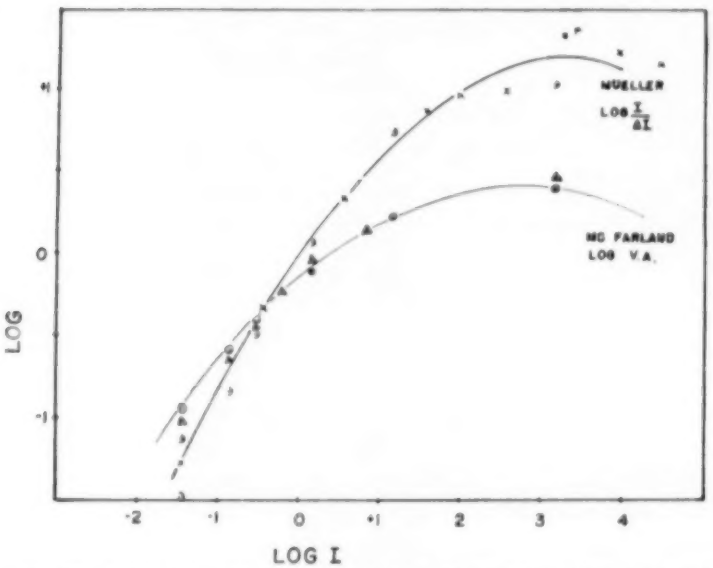

Fig. 6. Threshold values of log $I/\Delta I$ (data from Mueller[14]) and log visual acuity (data from McFarland[16]) as functions of log I.

different. To detect the presence of a figure requires merely that some part of the image presents a perceptible contrast to the ground. To orient a short line requires that the gradients in the two opposed directions can be discriminated, or if letters are to be recognized, that a whole system of gradients permits some analysis of form. The latter will require that the values for some or all of the factors of time, contrast or visual angle are greater than for the former. Obviously the difference between the tasks of presence versus orientation or recognition will vary greatly with the complexity of the figure. In the absence of appropriate data significant quantitative comparison is not possible. A rough check of data (Figure 7) from Hendley[5] and Blackwell[17] indicates that simple orientation of a short line is about ten times more difficult than noting the presence of a round spot of similar area.

The above analysis appears to justify the following conclusions. Visual acuity is not a unique capacity but rests on the same stimulus conditions as, for instance, the differential light threshold. Its peculiarities are in part conventional, in part quantitative, and in part due to the greater complexity of the percepts involved. The conventional peculiarities are that the visual angle has commonly been used as its

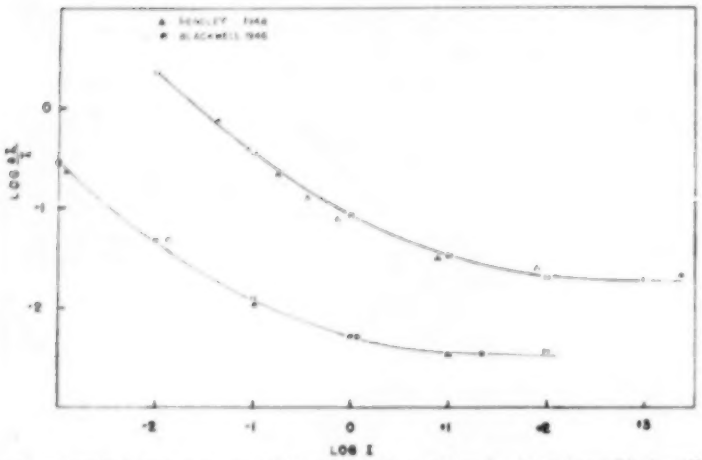

Fig. 7. Threshold values of log $\Delta I/I$ as a function of log I; (data from Blackwell[17]) for a circular test object 18.2 minutes in diameter, criterion presence and from Hendley[5] for a rectangular test object 20 by 40 minutes, criterion orientation.

measure rather than time or contrast, and that the results of testing have been reported as sensitivities rather than as thresholds. That either or both are convenient or useful conventions does not alter the fact that these differences are conventional and not inherent. Visual acuity presents a lower sensitivity (or a higher threshold), a quantitative difference from other visual tasks but no new factors are involved. The outstanding peculiarity of visual acuity is that the task presented by letters, the common test object, is perceptually more complex than noting the presence of an inhomogeneity of the field. The immense cultural importance of letters is indicated by the time spent by the average literate man in learning, recognizing and making letters. The literate and the illiterate man may have eyes which are equally good optical instruments and their native abilities may be comparable but because of their experience they bring very different abilities to the perceptual tasks. For this reason the psychometric precautions necessary in the use of letters are far greater than those of other tests. But this difference is again quantitative. Other tests, readily accepted as measuring "visual acuity," form a transitional series running from the simple orientation of a short line through the orientation of the Landolt C and the block E to the Snellen letters and beyond to the Jaeger near point test cards with printed sentences rather than isolated letters.

Analysis such as has been made of the stimulus situation putting

visual angle in its normal place in the total picture underlines the qualitative identity of the tasks discussed and sets the interesting quantitative differences in their proper perspective.

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ABSTRACT

STANDARDS FOR REFERRAL OF SCHOOL CHILDREN FOR AN EYE EXAMINATION. Special Report. Sight-Saving Review. 23.4.1953, (preliminary report): American Journal of Ophthalmology. 37.5.710-718.1954. (complete report).

Committees were appointed by the New England Ophthalmological Society and the Massachusetts Medical Society, Section of Ophthalmology and Otolaryngology, to conduct a joint study of the school vision test problem. The cooperation of the Harvard School of Public Health and the Children's Medical Center was obtained. By use of a questionnaire, information regarding standards which physicians use in their own offices and standards which they advocate that others use for referral were obtained and analyzed.

In the preliminary report it appears that the committees decided upon certain recommendations. However, in the later report the summary states:

"A preliminary survey of physicians by the questionnaire method has indicated that a considerable difference of opinion exists in regard both to their office practice and to their desires in regard to the standards which they would set for the referral of school children to them.

"This preliminary survey suggests that a further study of the problem of referral standards is desirable. In order to improve the efficiency of present vision screening methods and to improve their standing with the public as well as with practicing ophthalmologists, a clarification and better understanding of the present situation is necessary."

ROBERT E. BANNON

FIXATIONAL DISPARITY AND THE MAINTAINENCE OF FUSION IN THE HORIZONTAL MERIDIAN*

A. M. Mitchell† and V. J. Ellerbrock‡
School of Optometry, The Ohio State University
Columbus, Ohio

INTRODUCTION AND HISTORY

Binocular vision under ordinary circumstances occurs only when the two eyes are oriented so that fusion takes place. Fusion, at one time, was thought to occur when corresponding points were stimulated by the images of an object in space. This concept, however, has been changed. Fusion, according to modern thinking, occurs within a certain area which surrounds the corresponding point. This area is called Panum's area. Fusion, therefore, still can be maintained when the eyes are over or under converged by a few minutes of arc. This deviation of convergence from corresponding points, without loss of fusion, is called fixational disparity. Knowledge of the nature of fixational disparity is necessary for a complete understanding of binocular vision.

The phenomenon of fixational disparity has been observed and studied by numerous investigators. Perhaps the first to observe it was Wheatstone. When using a stereoscope, he found that configurations were fused even though they did not stimulate corresponding points. This observation led Panum to postulate that fusion was maintained within an area. This area has since been given his name.[1]

Lau, by the use of a haploscope, also investigated fixational disparity. With his target a center line is fixated binocularly while the peripheral measuring lines are seen monocularly and are adjustable. When fixational disparity is present, the peripheral lines are seen displaced in relation to each other. By adjustment of the lines, Lau could measure the extent of over or under convergence for a given point of fixation. He also noticed that during forced convergence, the eyes tended to lag somewhat behind the stimulus while fusion still was maintained.[1]

Lewin and Sakuma, and Ames and Gliddon also demonstrated fixational disparity with haploscopic targets.[2] Ames and Gliddon found a correlation in direction between the phoria and fixational disparity. The lag of the eyes was in the direction of the phoria. For their haplo-

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†Optometrist, M.Sc.
‡Optometrist, Ph.D. Member of faculty. Fellow, American Academy of Optometry.

scopic targets they used a peripheral binocular fusion stimulus and a central monocular measuring point.

The most comprehensive investigation of fixational disparity has been done by Ogle.[2, 3, 4, 5] By means of a target consisting of moveable, monocular, central verniers and peripheral fusion stimuli, he measured fixational disparity to 0.2 minutes of arc. Prisms were used to force vergence and place a stress on the fusional mechanism.[2, 3, 6] In the horizontal meridian he found that subjects fell into four groups.

The subjects in group one had a regular increase in fixational disparity with increased forced vergence: the majority of subjects fell into this group. Persons in group two, which accounted for approximately 10 per cent of the subjects, maintained approximately the same amount of fixational disparity over a wide range of forced vergence. Near their fusional limits, however, these subjects always had a sudden increase in fixational disparity. Less than 10 per cent of the subjects were included in group three. Their data were similar to group two except that no sudden increase in fixational disparity was found at the fusional limit. The subjects in group four had a change in fixational disparity only over a narrow range of forced vergence: outside of this range the disparity was unchanged. This last group consisted of subjects who had poor binocular co-ordination.

Ogle also investigated the effects of other experimental conditions on fixational disparity. He found that the more peripheral the fusion stimulus was placed, the greater the fixational disparity changed per unit change in vergence.[2, 3] Also, he found that plus and minus spherical lenses placed before the eyes altered the fixational disparity. For subject in group one, the curves were displaced in the divergent direction with plus lenses and in the opposite direction with minus lenses.[2] The equal blurring of vision in both eyes did not change the amount of fixational disparity, although the sensitivity of the subject was reduced.[2, 3]

The uniocular components of fixational disparity also were studied. It was found that two effects occur from fusion of noncorresponding points. First, both eyes could lose their primary subjective visual direction and attain instead a new compromise direction; second, only one eye might lose its primary subjective visual direction, taking on a direction coincident with that of the other eye. Subjects gave both responses.

With the same apparatus that had been used for investigations in the horizontal meridian, Ogle also studied fixational disparity in the vertical meridian.[5] In general, his results were similar to those which had been obtained in the horizontal meridian, except for the

fact that his data for fixational disparity as a function of vergence produced a straight line rather than a sigmoid curve. In addition, he found that the eyes would compensate for the prism induced stress. For example, if a prism of three prism diopters caused a change in fixation disparity of two minutes of arc, by continuous wearing of this prism the fixational disparity would gradually return to its pre-prism value. When this compensation had occurred, removal of the prism would produce a fixational disparity opposite in direction to that produced by the prism. Gradually this fixational disparity would return to normal. The time necessary for this recovery was found to be two to three times the original compensatory process.

Shepard also studied fixational disparity.[7] He found that with different target sizes, there was no change in fixational disparity. In a random sampling of subjects, he also noted that the condition of over convergence was much more prevalent than the reverse situation.

PURPOSE

Although all of the research described above has increased the understanding of fixation disparity manyfold, many facets of the phenomenon still remain unknown. Of particular interest is the variation of fixation disparity with prolonged stress on the fusional mechanism of the eyes. Does fixational disparity change with protracted use of the eyes? Does it vary with the stress on the fusional mechanism due, for example, to a large phoria? The answers to these and similar questions were the purpose of this investigation.

INSTRUMENTATION

Fixational disparity is measured in extremely small units, and thus many problems of instrumentation are presented. The apparatus of necessity must be capable of measurements to a sensitivity of 10 seconds of arc; also, it must have an amplitude of at least 8-10 minutes of arc. In addition the instruments must have certain other essential features. The target must provide a stimulus for binocular vision. Also, there must be two monocular stimuli, one to be seen by the right eye and the other by the left eye. Monocular stimuli will be seen in their primary subjective visual direction. Thus, if they are aligned one above the other, they can be used for measuring over or under convergence of the eyes. A further feature of an instrument is a means for forcing vergence so that fixational disparity may be measured under various stresses on fusion.

The stimulus used for binocular fusion in this study was designed by Allen[11] (see Figure 1). This target has a number of unique features. The horizontal grids provide a fine control of accommodation; in fact,

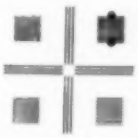

Fig. 1. The target used for maintenance of single binocular vision. The small monocular measuring points are shown in the upper right grid.

the 20/15 grid can not be resolved when the eyes only are 0.25 diopters out of focus. When blurred, the grid is seen as a solid square; such a change is easily apparent to the subject. Also the horizontal grid is unaffected by distortions from prisms oriented with their base-apex line parallel to the grid. Prisms thus oriented were used in the experiments for this investigation. Another feature of the target is that the grids and the central cross provide good fusional stimuli.

In the experiments the target was a high contrast negative illuminated from behind by a 7.5 watt frosted bulb. It was located 40 cm. from the subject's corneas and oriented perpendicular to the median sagittal plane of the subject's head. The target subtended a visual angle of 5 degrees. Since the experiments were done in a darkened room, only the transparent portions of the targets were visible to the subject.

The monocular measuring points in this instrument were projected into the plane of the binocular fusional target. They consisted of points of light which were 0.2 mm. in diameter. These points were located in the base of the instrument and were reflected into the subjects eyes by a semi-silvered mirror (cf. Figure 2). They could be superimposed on any part of the image of the binocular target by changing the position of the mirror. They always were located in a grid as shown in Figure 1.

Since the measuring points were plane polarized in opposite directions, analyzing polaroid filters before the subject's eyes made only one point visible to each eye.

The displacement of the moveable measuring point from vertical alignment was measured by an Ames 1/1000 inch spring loaded gauge. This gauge rested against a moveable arm: the arm itself was activated by means of an adjustable screw pressing against the opposite side. The gauge was calibrated in seconds of arc and had a sensitivity of 7.5 seconds. The relatively large vertical separation of the measuring points, plus the many horizontal lines of the binocular target, prevented any tendency of the subject to fuse the points binocularly. Because of their central locations, the points could be aligned easily and accurately.

Fig. 2. Apparatus used for measurement of fixational disparity. The monocular measuring points were located in the base of the housing for the target; they were localized subjectively in the plane of the target by use of the semi-reflecting mirror.

Prisms were used to force vergence; they were located 14 mm. from the cornea. Also it was possible to use lenses in place of the prisms. The prisms or lenses could be adjusted for any interpupillary distance and a headrest maintained a fixed position of the subject's head.

PROCEDURE

In all the experiments, the subject was instructed to adjust the moveable measuring point so that it was directly above the fixed point. However, to avoid a directional error, alignment alternately was made from the right and left. This procedure always was continued until a total of ten settings had been made.

At the commencement of each experiment a measurement was made of the alignment of the measuring points with the analyzing polaroids removed. Of course, with this arrangement each of the measuring points were seen binocularly; the mean of the settings provided a measure of the subject's concept of verticality. Then the polaroids were replaced and another measure of alignment of the measuring points was made. With these data it was possible to compute the fixation disparity; it is measured in minutes of arc by the angle subtended at the eyes of the subject.

The procedure so far explained was repeated on each subject on every day of participation in the experiments.

The next measurements were made during forced vergence. Vergence was usually forced with prisms, although occasionally lenses were employed. The subject was asked to fixate the target through the prisms. Settings were to be made only when the subject saw the fixated grid fused, and clearly. The subject was repeatedly urged to keep the grid single and clear, and to make no settings if it blurred. Continuous fixation was maintained, and continuous settings were made during the course of the experimental run. Time was also recorded for each setting. In this way a continuous record was made of the affect of a stress on fixational disparity.

The prisms were removed at the end of a given time. Now, a third type of measurement, the recovery measurement, could be made. The subject closed his eyes for five seconds while the prisms were removed, and then he resumed fixation of the target. As soon as fusion was obtained and the target was clear, settings were again made. These settings were continued until the measured fixational disparity had returned to its normal value.

If forced vergence had been placed on the eyes of a subject for more than fifteen minutes, no further experiments were performed that day. If the subject had participated in a forced vergence experiment for less than fifteen minutes, at least one hour of rest was provided before further data were taken. These precautions were taken so that fatigue and other possible effects would not influence further experiments.

Only subjects with a refractive error of less than 0.37 diopter were used in these experiments; their phorias varied from 5Δ exophoria to 4Δ esophoria at 40 cm. and their fusional amplitudes were normal from a clinical viewpoint. Seven men ranging in age from 20 to 37 years served as subjects.

RESULTS

When the eyes are forced to converge, a stress is placed on the fusional mechanism. This stress is revealed by a lag of the eyes behind the stimulus for convergence, i.e., fixational disparity in the direction of under convergence. As forced convergence is increased, the lag becomes greater within physiological limits. When a given amount of forced convergence is maintained for a period of time, the fixational disparity shows no tendency to change. That this is true regardless of the degree of forced convergence is shown in Figure 3. This figure also illustrates the direct relationship between forced convergence and fixational disparity. Other investigators have shown a decrease in the amount of

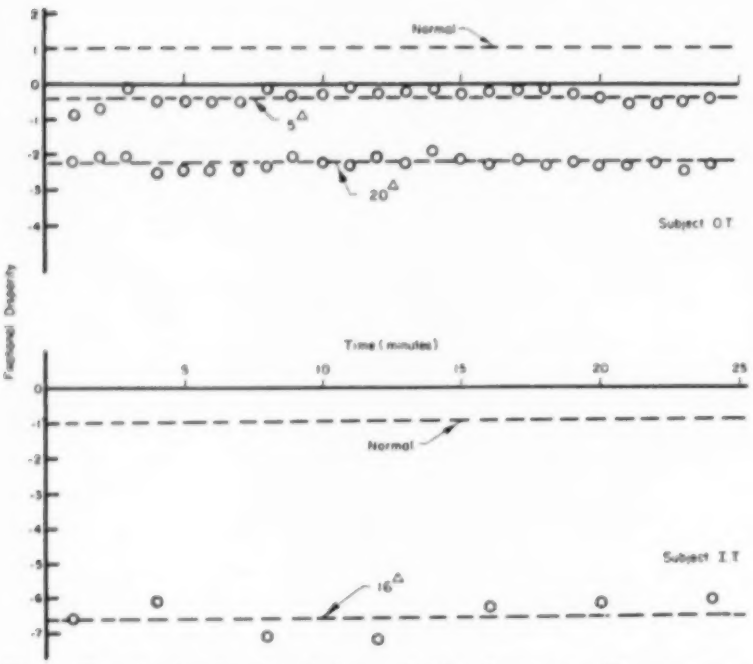

Fig. 3. Data showing the effect of time on fixation disparity for different amounts of forced convergence.

fixational disparity when vertical vergences are forced over a period of time. This decrease of fixational disparity does not seem to be present to any significant degree during prolonged forced convergence.

When the prism used to force convergence is removed the fixational disparity is in the direction of over convergence. However, with time the subject's fixational disparity gradually will return to normal (Figure 4). Frequently, a period of either diplopia or blurring of the target exists when the prisms are first removed. With one subject, blurring and diplopia would last as long as twenty minutes. For each individual the time required for the return of fixational disparity to its normal value varies with the amount of forced convergence and the length of time it was maintained (Figure 5). A great deal of variation is found, however, from subject to subject.

During forced divergence of the eyes, as in forced convergence, fixational disparity is encountered. The duration of forced divergence

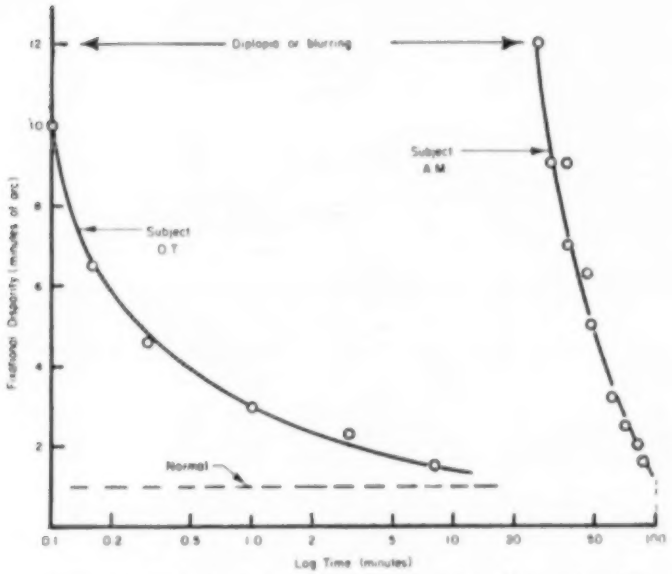

Fig. 4. Fixation disparity for two subjects upon cessation of ten prism diopters of forced convergence. The convergence was maintained for thirty minutes prior to removal of the prism.

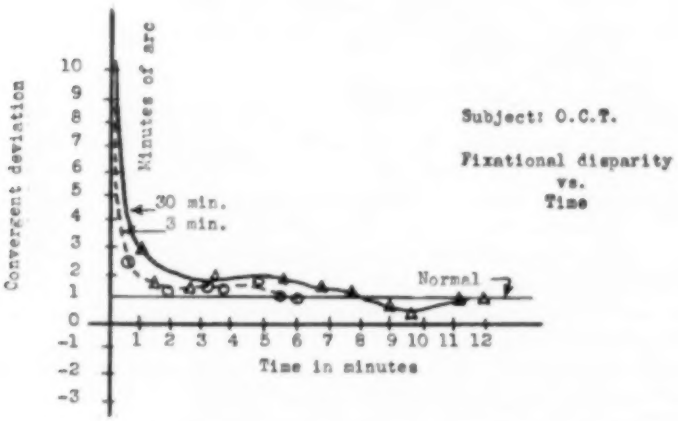

Fig. 5. The forced convergence for these data was maintained for three and thirty minutes. The stimulus for convergence was a ten diopter prism.

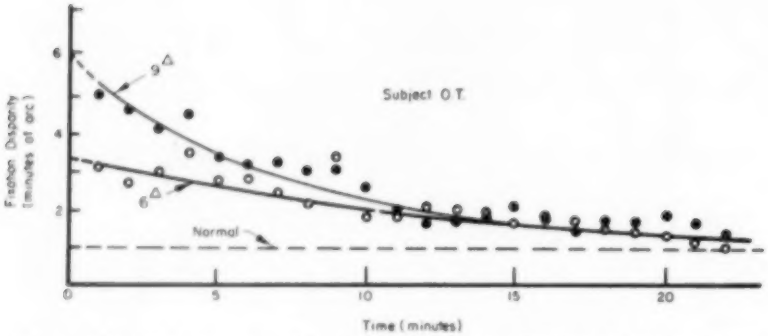

Fig. 6. Data illustrating the effect of time on fixation disparity induced by forced divergence.

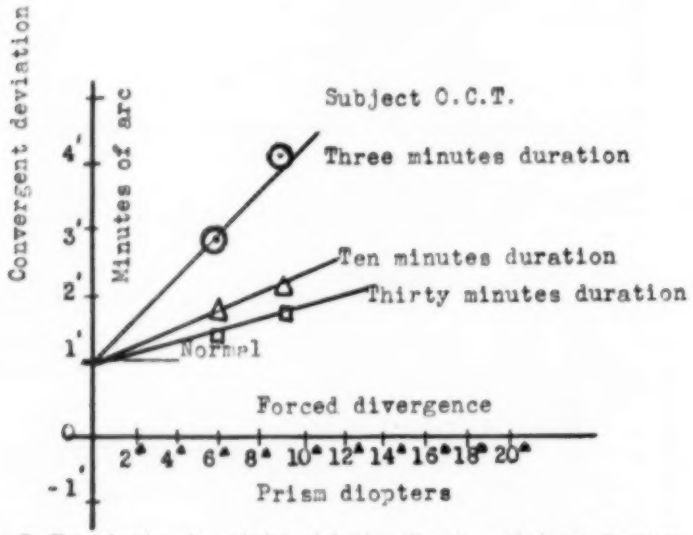

Fig. 7. Data showing the variation of fixation disparity with forced divergence for various periods of time.

is an important factor, however, since the longer the stress is maintained, the less is the fixational disparity. (Figure 6.) Most subjects have a complete return to their normal fixational disparity if sufficient time is given to make this adjustment.

Figure 7 shows the relationship of fixational disparity to various amounts of forced divergence. It shows that the duration of forced

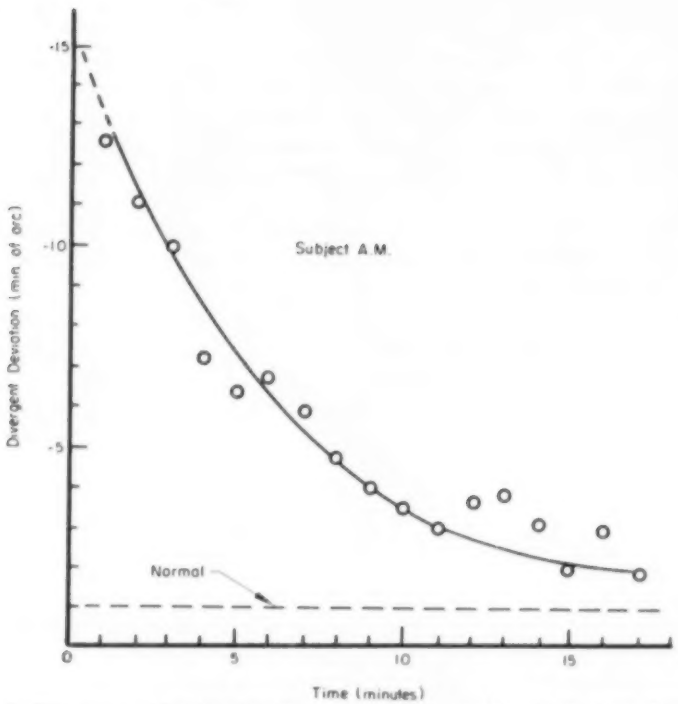

Fig. 8. The return of fixation disparity to normal upon cessation of six prism diopters of forced divergence. The divergence was maintained for thirty minutes.

divergence markedly affects the fixational disparity. If the duration of the forced divergence is made constant for all measurements, a direct proportional relationship is found between fixational disparity and forced divergence.

When the prism to force divergence is removed, the eyes now have a tendency to under converge and then slowly return to normal. (Figure 8.) The recovery curve obtained in this figure shows a similarity in shape to those found after forced convergence but there is great variation from subject to subject. In addition, the speed of recovery for a given subject varies with the duration and strength of the stimulus. Other important differences also deserve notice. There was no diplopia or blurring for any of the subjects used in the experiments on removal of the prisms regardless of the amount of prism power. Also, the initial portion of the recovery curve is extremely rapid so that within five to ten seconds fixational disparity changes two to

three minutes of arc. In general, complete recovery takes less time after forced divergence than after forced convergence.

These experiments have brought out a number of other characteristics of fixational disparity. Table 1 shows the variation of normal fixational disparity from day to day for three typical subjects. Statistical analysis by means of "t ratios" indicates that the variation found for each subject is probably not statistically significant.[18] Table 2 shows the measurements made on subject A.M. after a lapse of four months. These measurements are statistically different. Fixational disparity, therefore, while relatively stable for a short period of time, shows variation over longer periods.

TABLE 1
Variation of Normal Fixational Disparity from Day to Day for Three Subjects

Subjects				Subject
Date	A.M.	O.T.	Date	I.T.
Sept.	Fixation Disparity		May	Fixational Disparity
2	2'37"	1'00"	8	—1'15"
3	1'45"	1'30"	15	—1'51"
4	3'07"	1'07"	25	—1'15"
5	1'15"	1'00"	27	—1'00"
6	1'51"	0'45"	29	—1'30"
7	1'45"	1'00"	30	—1'07"
8	1'45"	1'07"		
9	1'37"	0'47"		
10		1'21"		
17	1'51"			

TABLE 2
Variation of Normal Fixation Disparity when Groups of Measurements Are Taken at a Four-Month Interval.
Subject: A.M.

May	Fixational Disparity	Sept.	Fixational Disparity
1	1'45"	2	2'37"
2	1'45"	3	1'45"
5	0'37"	4	2'07"
7	0'51"	5	1'15"
13	0'30"	6	1'51"
18	0'37"	7	1'45"
20	0'51"	8	1'45"
25	2'30"	9	1'37"
29	0'37"	17	1'51"
Mean	0'54"	Mean	1'50"

All subjects used in these experiments had high sensitivity under small amounts of stress. Under increasingly large amounts of stress, however, sensitivity progressively decreased a shown in Table 3.

Table 4 shows the standard deviation at the beginning and end of continuous forced convergence for thirty minutes. There is no significant change in sensitivity from the initial phase to the end of this period, which would indicate that the stress on the convergent fusional

TABLE 3
Variation in Sensitivity in Measurements of Fixational Disparity for Subjects Under Various Amounts of Forced Convergence.

	Subject: A.M. Standard Deviation	Subject: O.T. Standard Deviation
Normal convergence at 40 cm.	0'24"	0'13"
5 prism diopters of forced convergence	0'39"	0'18"
10 prism diopters of forced convergence	0'39"	0'24"
20 prism diopters of forced convergence	0'52"	0'30"

TABLE 4
Variation in Sensitivity of Subjects During Continuous Forced Convergence for 30 Minutes.

	Subject: A.M. Standard Deviation	
	First 5 min.	Last 5 min.
5 prism diopters of forced convergence	0'42"	0'36"
10 prism diopters of forced convergence	0'35"	0'40"
20 prism diopters of forced convergence	0'57"	0'49"
	Subject: O.T. Standard Deviation	
	First 5 min.	Last 5 min.
5 prism diopters of forced convergence	0'25"	0'23"
10 prism diopters of forced convergence	0'17"	0'22"
20 prism diopters of forced convergence	0'32"	0'34"

mechanism has not been altered during prolonged forced convergence. The data were repeatable for all subjects. As was previously indicated, normal fixational disparity did change over a period of two to three months.

Forced convergence can be produced by plus lenses as well as base-out prisms. If the A.C.A. ratio* and the power of the lenses before the eyes is known, it is possible to predict the stress placed upon the positive fusional convergence. The data in Figure 9 are plotted from such an analysis. They demonstrate that there are no significant differences in fixational disparity when equal amounts of forced convergence are produced by either lens or prism power.

The subjects reported their subjective symptoms during all the experiments. In most cases the discomfort experienced was only slight even with large amounts of prism. Occasionally, however, a subject reported a headache a few hours after completion of the day's experiment.

Subjects felt relatively confident of their settings with small amounts of forced vergence. They reported, however, considerable difficulty in making settings with large amounts of prism due to an

*The A.C.A. is the ratio of accommodation convergence to accommodation. It expresses the change of convergence in prism diopters per diopter of accommodation. For example, an A.C.A. ratio of six means that six prism diopters of accommodative convergence are produced for each diopter of accommodation.

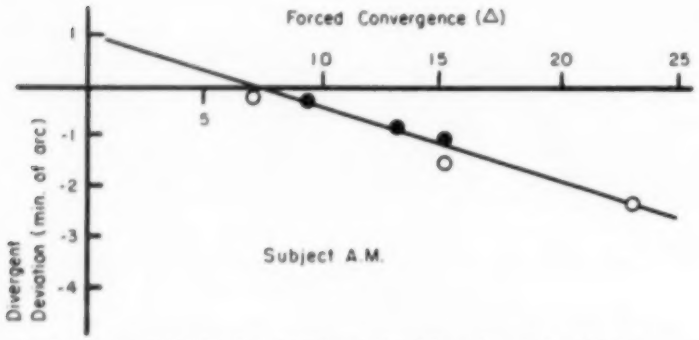

Fig. 9. Graph comparing fixation disparity produced by prisms and equivalent amounts of plus spherical lenses. The data plotted as solid points were obtained with lenses.

instability of the measuring points. Even so, the results were surprisingly accurate. Most of the subjects had no difficulty in keeping the target fused and clear during the experiments, once fusion and adequate accommodation had been obtained.

DISCUSSION

Compensation or adaptation of the eyes to a prolonged stress on fusion has been demonstrated by a number of investigators who have used methods of measurement other than fixational disparity. Hoffmann and Bielschowsky found that tonic innervation resulting from fusional movements did not disappear immediately upon removal of a stimulus.[6] Ellerbrock noted that if the fusional stress was gradually increased, there would be a higher fusional amplitude than what would normally be obtained.[8] Alpern and Morgan found that the phoria measurement in the horizontal meridian was affected by forced convergence.[14] Alpern also found this to be true, to a lesser degree, of forced divergence.

With the employment of fixation disparity, Ogle demonstrated compensation to a fusional stress in the vertical meridian. In this paper, a similar compensation or adaptation has been demonstrated for forced divergence in the horizontal meridian. No such compensation, however, has been demonstrated for forced convergence. The mechanisms which maintain fusion during convergence seem to be unique in this respect.

The fact that fusional convergence is different from other fusional movements is further shown by studies of recovery curves. The curves of forced convergence for a subject usually require a longer period for recovery than those of divergence. On these bases, it appears that fusional convergence is mediated by a different mechanism or at least controlled in a different way than fusional movements in other direc-

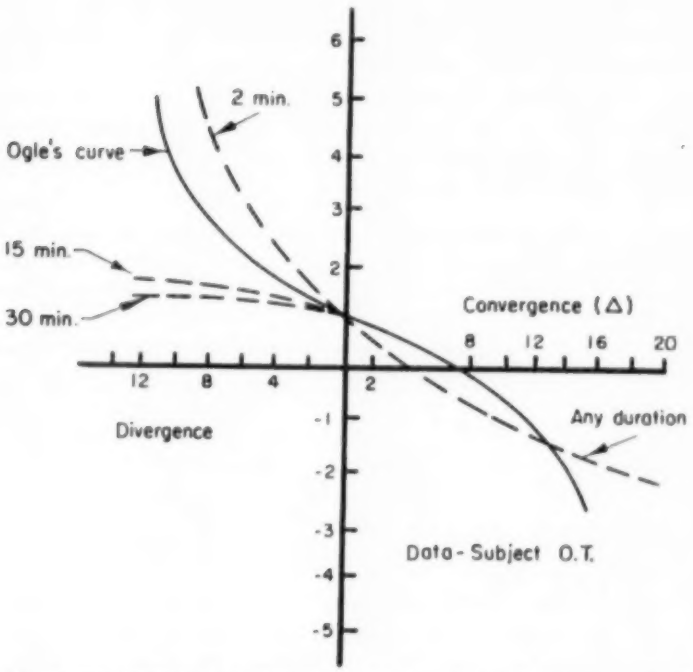

Fig. 10. Curves illustrating the effect of the duration of forced vergence on fixation disparity. These curves are compared to the typical sigmoid curve of Ogle. The notations on the curves indicate the duration of forced vergence prior to a measurement of the fixation disparity.

tions. The explanation for this difference may be related to the unique features of convergence. For example, accommodation is closely linked with convergence: many subjects will tolerate blurred vision in order to maintain fusion. Psychic convergence is another component of convergence. Still another unique feature of convergence is its voluntary control. These aspects of convergence may play a part in its unusual nature or may be products of the mechanism of fusional convergence.

In presenting the findings of his studies, Ogle plotted fixation disparity as a function of vergence. When this was done, a characteristic sigmoid curve was obtained. If the results of this investigation are plotted on a similar graph, the curves given in Figure 10 are obtained. For comparison, the sigmoid curve from Ogle is included. Obviously, the parameter of time plays an important part in determining the shape of the curve.

The use of fixational disparity as a clinical measure for determining the status of the fusional mechanism may have merit. Since measurements are made during fusion, fixational disparity seems to be a much more direct method of analysis than the phoria. In this investigation, fixational disparity did not adapt during forced convergence; therefore, it may be of considerable value in clinical analysis of the convergent fusional mechanism.

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CLINICAL REPORT OF THE CORRECTION OF ANISEIKONIA IN CASES OF LOW REFRACTIVE ERROR*

Arene T. Wray†
Los Angeles, California

The purpose of this paper is to call attention to the type of case in which the optometrist would not expect to find aniseikonia on the basis of the refractive error.

A question frequently asked is "when would you suspect that a patient has aniseikonia?" For patients with anisometropia the possibility of a size difference induced by the lens correction is always in the mind of the optometrist, especially when the lens correction fails to eliminate the asthenopic symptoms.

Burian states, "In cases of refractive anisometropia, for instance, corrective refractive lenses of different power located at the same distance in front of each eye will give rise to the formation of images of different size on the two retinas. . . . It is a new concept that a difference in the size of the ocular images may also exist in cases in which there is no difference in the size of the dioptric images."[1]

In summarizing the clues that would lead the optometrist to suspect aniseikonia Bannon[2] lists the following:

"1. Symptoms unrelieved by the proper refractive and/or prismatic correction.
"2. The need for an anisometropic correction.
"3. The patient's report that he is more comfortable with monocular vision.
"4. Spatial localization difficulties."

When a patient, who has been given a very moderate refractive lens correction, returns complaining that his asthenopic symptoms still persist, the optometrist will usually recheck his refractive data. Finding no change in the prescription indicated, the fundi negative, the binocular functions within normal ranges, he might well decide to investigate the possibility of an aniseikonic condition.

CASE REPORT 1

Mrs. M.C., librarian, age 36, seen January 28, 1954, at which time the following history and symptoms were recorded. She has had many pairs of lenses since age 18 and none has been satisfactory. She recently had a series of anti-histamine shots with negative results. Her

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†Optometrist. Fellow, American Academy of Optometry.

right eye pains: unilateral headache on the right side of the head; close work brings on the headaches; she does not read newspapers or look at television as they cause headaches. Bright lights and sunshine bother her eyes. She has difficulty in judging the distance of an oncoming car when driving at night. She sees a second, or ghost image of telephone poles behind each pole. When looking at a curtain, one side seems to vibrate.

The patient has had two pairs of lenses which she tried to use alternately, but both were unsatisfactory when reading. The first, prescribed three years ago was: O.D. —0.25 D. sph., O.S. —0.50 D. sph. The second pair, prescribed 18 months ago was, O.D. —0.25 D. sph., O.S. —0.25 D. sph. $\bigcirc$ —0.25 D. cyl. axis 5. Her uncorrected vision was O.U. 20/16-1. O.D. 20/20. O.S. 20/20-1. The ophthalmometer findings were O.D. 157/43.00 and 67/44.50. O.S. 178/43.00 and 88/44.00.

The refractive prescription finally arrived at was: O.D. —0.50 D. cyl. axis 135, O.S. —0.50 D. cyl. axis 180. The patients visual acuity with the above was: O.D. 20/15-1. O.S. 20/16-2. The muscle balance was 2Δ exophoria for distance and 6Δ exophoria at 40 cm., gradient 4/1.00, abduction 7/6 with difficulty. The adduction was not measured as the base-out prisms seemed to upset her. The patient's positive relative accommodation was 1.00 D., her negative relative accommodation 1.00 D. to blur and 2.00 D. to blur-out. The positive fusional reserve was 16/20/16 and the negative fusional reserve was 12/24/16. Visual skills tests revealed alternating suppression, Keystone DB4 card gave simultaneous binocular vision with momentary fusion, DB5 card (4 balls at 40 cm.), no fusion, DB6 card stereopsis test passed. Aniseikonic measurements on the space eikonometer gave the following findings: x90 L½% ± ¼%. x180 L 1.87% ± 3/8%. Delta —0.4 ± 0.1. The following prescription for the ametropia and aniseikonia was ordered. O.D. —0.50 D. cyl. axis 135. O.S. —0.50 D. cyl. axis 180 with a 1¾% magnification axis 25.

After wearing the lenses for three weeks the patient returned for a progress report and stated: "This is the first time in my whole life that I have gone this long without a headache." She was able to type and work on charts for long hours without fatigue and the symptoms were entirely relieved.

CASE REPORT 2

Sister T.A., a nun, age 28, teaches in a parochial school, was seen May 3, 1951. She was wearing iseikonic lenses which had been

prescribed in 1946. Prior to getting these iseikonic lenses she had suffered headaches constantly. Her symptoms, when she consulted me were the following. Lately the lenses annoy her and she wants to remove them "and throw them across the room." Her eyes tire after reading 1½ hours, but she does not have any headaches or eyestrain. The patient was wearing O.D. +0.75 D. sph. ⊃ +0.50 D. cyl. axis 105. O.S. +0.62 D. sph. ⊃ +0.37 D. cyl. axis 75, ⊃ ½ % magnification axis 90. Her visual acuity was O.D. 20/15-1. O.S. 20/15.

The test for aniseikonia on the standard eikonometer showed the right image smaller in the vertical meridian to the extent of 3/8% with a sensitivity of ±3/8%, and the right image larger in the horizontal meridian to the extent of 1⅝ % with a sensitivity of ±⅛ %. The muscle balance and relative fusional reserves were normal with the exception of the positive fusional reserve which was x/20/8 as compared with the negative fusional reserve of 22/24/16. The visual skills tests revealed some suppression of the left eye, stereopsis only fair and poor foveal fusion. The ophthalmometer findings were O.D. 10/40.75 and 90/41.75. O.S. 170/41.25 and 80/42.00. The final prescription for ametropia and aniseikonia was: O.D. +1.00 D. sph. ⊃ +0.75 D. cyl. axis 105. O.S. +0.75 D. sph. ⊃ +0.50 D. cyl. axis 55 ⊃ 1⅝ % magnification axis 90.

This change in prescription was a small increase in the correction of the hyperopia and the astigmatism, a 20 degree change in the axis of the cylinder for the left lens, and an increase in the aniseikonic correction of 1⅛ %, i.e. from ½ % magnification at axis 90 to 1⅝ % at axis 90. Daily exercise with vectograms was also prescribed.

The patient returned for a routine check-up in August, 1953, reporting the eyes entirely comfortable.

CASE REPORT 3

Mrs. L.M., a stenographer, age 43, was seen July 10, 1951. She was wearing iseikonic lenses which had been prescribed in St. Louis, eleven years previously. This old prescription was O.D. +0.75 D. sph. ⊃ +0.12 D. cyl. axis 180. O.S. +1.00 D. sph. ⊃ +0.12 D. cyl. axis 15 ⊃ ½ % magnification axis 90. With this correction the patients visual acuity was O.D. 20/22-1. O.S. 20/20-2. She stated that she had difficulty in seeing small print and that her eyes made her nervous. After the refractive and aniseikonic measurements were made, the final prescription was: O.D. +0.75 D. sph. ⊃ +0.25 D. cyl. axis 165 ⊃ 1% magnification axis 180. O.S. +1.25 D. sph. ⊃ +0.50 D. cyl. axis 15. With the new correction the patient's corrected visual acuity was 20/16-2, for O.D. and 20/16-2 for O.S. To this correc-

tion was added O.U. +1.25 D. sph. for reading. The ophthalmometer findings for this patient were O.D. 25/43.62 and 105/44.50. O.S. 5/43.50 and 65/44.12.

The patient was seen again in April, 1953, at which time there was need for a moderate increase in the ametropic and presbyopic corrections, the aniseikonic element remaining the same.

This patient also reported extreme ocular discomfort previous to receiving her first iseikonic lenses in 1950, which was a correction of only ½ % meridional magnification.

SUMMARY

Three cases are reported in which the ametropic corrections were very moderate in amount, the spherical component ranging from zero to plus one diopter and the cylindrical component from one-eighth to one-half diopter (see Table 1). All three patients had histories of years of ocular discomfort unrelieved by any ametropic correction. Their iseikonic lenses gave them complete relief from their ocular discomfort. It will be noted that the aniseikonic correction in all three cases was meridional in character and ranged as follows: Case Report 1, M.C., 1¾ % magnification axis 35. Case Report 2, T.A., the first iseikonic correction in 1946 was ½ % magnification axis 90. The second iseikonic correction in 1951 was 1⅜ % magnification axis 90. Case Report 3, L.M., the first iseikonic correction in 1940 was O.S. ½ % magnification axis 90. The second and third iseikonic corrections in 1951 and 1953 were both O.D. 1% magnification axis 180.

TABLE 1.

Case		Sphere	Cylinder
M. C.	O.D.	zero	—0.50 D. axis 135
	O.S.	zero	—0.50 D. axis 180
T. A.	O.D.	+0.75 D.	+0.50 D. axis 105
	O.S.	+0.62 D.	+0.37 D. axis 75
L. M.	O.D.	+0.75 D.	+0.12 D. axis 180
	O.S.	+1.00 D.	+0.12 D. axis 15

Summarizing the data received from a questionnaire which he had sent to all the aniseikonic clinicians in December, 1949,[3] Bannon reported that an average of 58 per cent of the cases receiving aniseikonic corrections were given meridional corrections at axis 90 or axis 180, 15 per cent received oblique axis corrections, and only 27 per cent received overall magnification correction. In 1954 the same questionnaire revealed the figures to be 46 per cent, 18 per cent, and 36 per cent, for these same categories.[4] In both of these reports the lower limit of iseikonic correction was given as 75 per cent average. It would

therefore appear that low amounts of meridional aniseikonia in persons with high sensitivity will produce intense asthenopic symptoms.

3261 WEST SIXTH STREET,
LOS ANGELES, CALIFORNIA

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ABSTRACT

THE LYNWOOD VISUAL WELFARE SCHEME. Edith M. Beattie. British Journal of Physiological Optics. 11.4.233-244. 1954.

The author refers to this report as "possibly the most comprehensive scheme of its kind so far carried out in British industry."

The investigation deals with "eye strain difficulties" of 213 employees of a British textile factory. Each employee was considered in relation to the visual requirements of the task involved, and in 126 cases individually prescribed work glasses were given. Also, in one department, considerable improvement resulted by altering the positions of existing fluorescent lamps.

As a result of the visual program (scheme), eyestrain vanished from the factory and certain operations lost their reputation of producing eyestrain and headaches. Furthermore, the workers were deeply appreciative of the management's regard for their welfare, and the workers attained more easily the high standard of work required of them: also, where statistics were available, a significant rise in output was evident.

In general, the work done in this factory by the employees investigated consisted of very fine detail seeing at close distances of 5 to 10". The special work glasses that were individually determined and prescribed are described only as "the lenses, which were technically complex, were calculated to relieve all eye and eye-muscle strain caused by the abnormally close working distance, and also to give a magnification of about 25 per cent." The workers were advised to wear their special glasses for work only and to remove them for walking about—"as vision would be blurred for any distance over 10 inches." Hence, it is apparent that a fairly fu correction was given for the near working distance.

ROBERT E. BANNON

BOOK RETINOSCOPY*

Chester H. Pheiffer†
College of Optometry, University of Houston
Houston, Texas

Book retinoscopy is the use of the retinoscope to determine the changes in accommodation that occur while an individual is reading. In a more general sense, the term has been used to designate the retinoscopy performed while the individual is performing almost any kind of visual task.

Many retinoscopic observations, made while the subject was reading or in a pleasant or unpleasant affective state, have been reported, but few published. The subjects of these observations have been aphakics, professional baseball players, scientists, optometrists, children, good and poor readers, and babies. The optometry students at the University of Houston observe the phenomenon in their visual training laboratory. The demonstration consists of one student scoping a second student who is reading material that has been inverted.

The reporters of these observations on book retinoscopy state that when the reader encounters difficult material, he shows an increase in the amount of accommodation in use and in the color and quality of the reflex. Our laboratory demonstration substantiates these reports in that when the reader encounters a word that he must puzzle out, his accommodation increases over the amount shown when the words are readily recognized.

The first to observe and report on book retinoscopy was Getman. His work at the Yale Institute is utilized by Gessell, et al,[1] as a measure of developmental levels. In *Vision, Its Development in Infant and Child*, the color of the reflex, the change in the refractive power, and meridional changes are correlated with developmental levels and types of performance.

Skeffington[2] has reported on a study of nine children at the Temple University Reading Clinic. The visual tasks required of the children in this study consisted of picture identification and matching, reading material of various levels of difficulty, and number recognition. The reported results were: (1) changes in the amount of accommo-

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The data presented in this paper were collected by the author's students while he was teaching at the Southern College of Optometry.
†Optometrist, Ph.D., member of faculty, Fellow, American Academy of Optometry.

dation in use from material to material for the same child, but not in the same direction for all children. Some children showed greater amounts of accommodation in use when working with pictures; others, when reading; and so forth. (2) The changes in accommodation varied from 0.50 to 1.50 diopters for the same child on different tasks. (3) The better readers showed frequent changes in accommodation of a rather rapid nature and on the order of 1.00 diopter in magnitude. The children who had difficulty dealing with the material showed very little fluctuation and smaller amounts of accommodation in use, as measured by minus lenses to secure neutrality, than those more able to handle the material. The poor reader was characterized by rigid, static accommodation.

This work was begun as an exploratory investigation of the statement that the amount of accommodation in use is increased when the reader encounters a difficult word or passage.

EXPERIMENTAL PROCEDURE

A padded head rest was used to hold the subject's head relatively immobile. The material to be read was supported by a rack at a distance of sixteen inches from the subject. By placing a beam splitter in front of each of the subject's eyes at an angle such that the light reflex from the subject's eye was reflected into the eye of the retinoscopist, the neutralizing lenses and the retinoscopists could be placed to the side of the subject and out of his line of sight. This enabled the subject to read with nearly normal binocular vision as the only interference with his reading was the light from the retinoscope. The light rays from the material to be read passed through the beam splitters into the eyes of the subject. The scoping distance was sixteen inches. Findings were taken at specified intervals during the reading period. Neutrality was secured in one meridian only.

RESULTS

The materials to be read in the first experiment were a near point card; SCOTOPICS (the school paper), and passages from PHYSIOLOGICAL OPTICS by Zoethout. It was thought that the material varied enough in difficulty to provide the expected changes in accommodation. While the changes found were on the order of 0.50 diopter from material to material, they were highly individual and not in terms of supposed difficulty. Analysis of the protocols revealed that the increases in accommodation were associated with the subject's interest in the material.

The second experiment again used an article from SCOTOPICS that was selected by the observer: *Essentials of Psychological Testing* by Cronbach, and *Statistical Analysis* by Peters & Van Vorhis. The

observer continued to read for 15 minutes. A finding was obtained at the beginning and at five minute intervals. To maintain interest at a high level, the observer was informed that he would be given a test for comprehension.

In general, it was found that accommodation increased on the order of 0.75 diopter for the three subjects over the 15 minute period if the material were difficult or interesting, otherwise there was no change. One subject showed the same amount of accommodation regardless of the material used. The range of accommodation was from 20 inches, when the observer started to read, to 11 inches near the end of the session. One observer started reading at 16 inches and stayed at 16 inches during the entire session. Analysis of the protocols again revealed interest to be the important factor.

The third experiment used the chapter on electro-magnetic theory from *Introduction to Physical Optics* by Robertson and *Getting the Most Out of Life*, an anthology from READERS DIGEST. Ten students served as subjects. They read each selection for 15 minutes. Findings

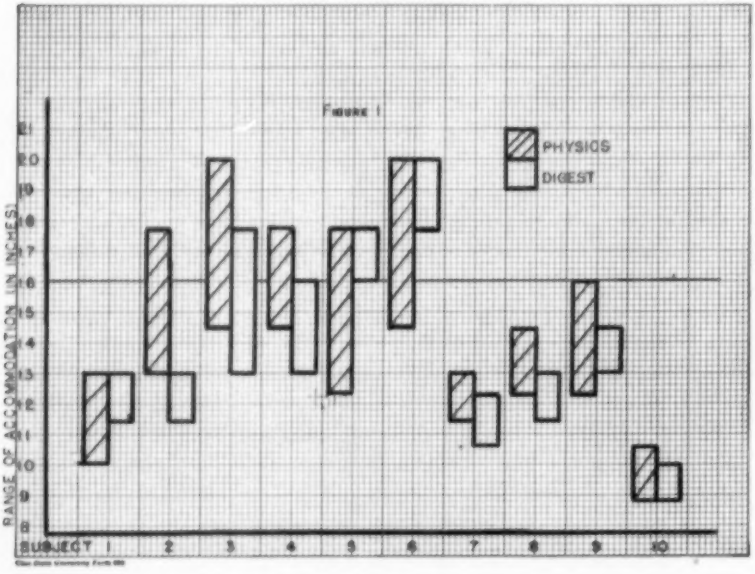

Fig. 1. The ranges of accommodation (in inches) displayed by each of the 10 subjects while reading the two types of material.

were obtained at the beginning and at five minute intervals. With one exception, no attempt was made to motivate the subjects.

The ranges in accommodation, shown in Figure 1, concur with the two previous studies in that the closest point of clear vision was 10 inches and the farthest point was 20 inches. The average range for the 10 subjects was 4.3 inches. Subject 10, a corrected myope, showed more than the usual amount of fluctuation at the 10 minute finding and shortly thereafter reported that the material was blurred. At this time the subject was accommodating for approximately nine inches.

The amount of accommodation in use at the beginning of each reading session is shown in Table 1. Five subjects showed no difference in amount for the two materials. Four showed a greater amount with the DIGEST material; one with the physics material. Since the DIGEST material was less difficult than the physics material, this trend toward a greater amount of accommodation in use when beginning to read the DIGEST must be due to interest.

TABLE 1

Subject	P.L.	R.D.	Δ
1	—0.50	—0.50	0.00
2	—0.50	—0.50	0.00
3	+0.50	—0.50	—1.00
4	0.00	—0.50	—0.50
5	+0.25	+0.25	0.00
6	+0.50	+0.50	0.00
7	—0.75	—1.25	—0.50
8	—0.50	—1.00	—0.50
9	—0.75	—0.50	+0.25
10	—1.50	—1.50	0.00

Accommodation in use by each subject on each material at the beginning of each session and the difference (RD-PL).

Accommodative changes noted during the 15 minute reading period were of five kinds: (1) trend towards increased accommodation, (2) trend towards decreased accommodation, (3) no change, (4) considerable variation with no particular trend, (5) rapid changes in accommodation with or without a trend. All of the subjects displayed the fifth kind to some degree. The amount of this variation was 0.50 to 0.75 diopter and concurs with the observations made by other workers. Since this change may occur several times during the reading of a line or not at all, it is in all probability not due to the retinoscopist being on or off the visual axis.

Seven of the subjects made greater changes in accommodation when reading physics material (0.50 to 1.00 diopter) as compared to the DIGEST material (0.25 to 0.75 diopter). The other three sub-

jects showed the same amount of accommodative change for both materials.

When the amount of accommodation in use at the beginning of the session was compared with that in use at the end of the session, it was found that five subjects showed an increase, three no change, and two a decrease when reading physics. With the DIGEST material, one subject showed an increase, seven no change, and two a decrease in accommodation. This substantiates the concept that the amount of accommodation in use is increased when the difficulty of the material is increased.

Of the two subjects who showed a decrease on the physics material, one, subject 2, reported loss of sleep during the previous night and that his eyes were tired and burning. His protocol showed that in a short time he was just reading words. As the effort to comprehend or the search for meaning was no longer attempted, the amount of accommodation in use was decreased. The beginning accommodation for this subject was the same for both materials. The DIGEST material was not difficult and occasionally interesting. These factors explain why there is no overlap in the range of accommodation used by this subject when reading the two different materials.

Subject 8 was informed that he was to be given an article to read that was slightly risque. Shortly after he began to read, he discovered that such was not so. His accommodation decreased 0.50 diopter.

It is interesting to note that a number of the subjects accommodate for a plane closer than the plane of regard. One is led to wonder if these subjects customarily hold their material closer than sixteen inches. One is also led to wonder if, when reading interesting material or a difficult one from which meaning is sought, these subjects tend to bring their material still closer as they increase their accommodation and how far the process continues.

The amount of accommodation in use when an individual is reading is dependent on his interest in the material and the difficulty of the material for him. Interest is the simpler of the two factors in that there is a direct relation between the two in so far as can be determined from subjective protocols. Difficulty of the material is not so simple in that an increase in difficulty, be it a word, passage, or the complete text, may bring about either an increase or decrease in the amount of accommodation in use. If the increase in difficulty is not accompanied by a desire for meaning, it is accompanied by a decrease in the amount of accommodation in use. On the other hand, if the increase in difficulty is accompanied by a desire for meaning, there will be an increase in the amount of accommodation in use.

Since we seek meaning as a result of interest, the main factor determining the change in accommodation as a material is read is interest. Interest is an expression of the individual's personality makeup and consequently we have again evidence of the important relation between perception and personality which is of so much interest to many present-day researchers.

The relation between the personality of the poor reader and his accommodative changes probably depends on the length of time he has suffered from, and the particular adjustments he has evolved to meet the problems that have arisen as a result of his poor reading ability. A more complete discussion of the relation between the accommodative changes, personality, and performance of the poor reader must await further research.

CONCLUSIONS

This writer is quite aware of the many inadequacies of the material presented here and recognizes that these conclusions are of a tentative nature only. It is believed that the importance of these concepts to an understanding of visual performance, their implications for various debated optometric problems, and especially and most importantly their potential heuristic value, justifies their presentation at this time.

1A. When material is read with interest or there is a search for meaning, accommodation is postured closer to the reader than the plane of regard.

1B. Under these conditions: accommodation increases when the material becomes difficult for the reader to comprehend and decreases when the material is readily comprehended.

2A. When the material is so far beyond the comprehension level of the reader that he cannot secure meaning, accommodation is maintained at or beyond the plane of regard.

2B. The same accommodative state exists when the material is readily comprehended but is not interesting.

3. In practically all cases, accommodation cannot be postured closer than 10 inches, when the material is at 16 inches, without a blur or a demand to move the material closer to the reader.

4. Accommodation is not postured farther from the reader than 20 inches when the material is at 16 inches.

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PERCEPTION TRAINING FOR TELEPHONE INFORMATION OPERATORS*

Mary Jane Hurt†
Los Angeles, California

The duties of telephone information operators are exceptionally demanding on near point visual skills. The job of looking up hundreds of listings as rapidly and accurately as possible in directories made up in six and seven point type, all during a regular working day, puts an unusually heavy demand on the accommodative-convergence mechanism.

If there has been adequate visual screening of applicants for this job, the operator should start her career visually well equipped for this sort of continuous near point visual activity. Even if, from a purely physical or refractive standpoint, the employee is visually adequate, she may not be suitable for the job without the proper perceptive skills. These skills must be sufficiently developed to allow her to scan the many hundreds of pages of small print every day and locate listings accurately with the very minimum of visual effort and fatigue.

When the operator receives the customer's order of a name or address for which she is to locate the number, she must first locate the page in the directory the listing is on, then scan the columns of listings until the correct one is located. Then she must perceive and interpret the correct telephone number to the customer. If the listing is not found exactly as the customer has given it to her, she will scan the page or other pages for listings that approximate the order given and suggest such listings, noting the manner in which they differ from the original order.

The type of reading the operator is therefore doing falls into the category of "scanning for recognition." Although this is one of the easier reading skills it none-the-less puts an extremely heavy burden on the visual mechanism when performed for so many continuous hours on such fine print. Since the perceptual skills involved are: visualizing the listing she seeks as it will appear in print; rapid recognition of the accuracy of the detail of the printed listing, and correct interpretation of the corresponding telephone number. Any training which increases these skills will therefore allow her to perform more efficiently, with less mental confusion, more eye-mind coordination, and lessened

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†Optometrist.

fatigue, as well as reduced strain on the visual mechanism.

Perception training based on the use of the tachistoscope and discussion topics on how to achieve better eye-mind coordination should then prove particularly beneficial to employees in this job category. Such a training program has been instituted as an experimental project in one information office.

The office selected for the pilot project was the Axminster Information office, Richmond District, West Traffic Division, Los Angeles.

The training program was designed to: [1.] Increase the accuracy by: (a) Less transposing, or confusion of like digits. (b) Accurate retention of the number so the customer is not allowed to repeat the number back incorrectly without being corrected. (c) Creating a habit pattern of seeing each listing in its entirety as a column is checked to prevent overlooking the listing. (d) Establishing an accurate visual memory that reduces an unnecessary amount of scanning.

[2.] Decrease employee's fatigue by: (a) Comprehending more with each eye fixation, and building up better eye-mind coordination so that fatigue from the constant visual effort will be decreased. (b) The development of self-confidence for the purpose of creating a more relaxed, less irritable individual able to perform with less tension.

[3.] Increase the number of listings located as a result of: (a) Increasing the operator's ability to scan a column of listings rapidly and accurately so that more listings will be located that are beyond the required limits of search, and more "probables" will be seen and suggested.

[4.] Establish better company-employee relations by emphasizing to the employees the personal benefits they derive from the training as: (a) Reduced fatigue on the job. (b) Improving her skill on the job for more rapid advancement. (c) Increased reading skills and efficiency, and better concentration ability.

The training was patterned to achieve the following: (1) Decrease the number of fixations per line of print. (2) Increase the span of recognition. (3) Increase the speed of recognition, by decreasing the duration of each eye fixation. (4) Decrease the number of regressions. (5) Establish better eye-mind coordination by visualization and memory retention exercises.

PROCEDURE

Subjects: Fifty-six subjects were selected from the Axminster office for training. These subjects were representative of the entire office force as to age, seniority, and operating efficiency. Seven of the group were supervisors. Of the initial fifty-six, fifty-four completed

the training program and thirty-seven of these were at the office for the three-month follow-up.

Diagnostic Procedure: [1.] Visual Skills Record. The Bausch and Lomb Orthorator was used to determine for each subject: (a) Visual acuity. Both monocular and binocular at the near point and at the distance. (b) Phorias. At the near point and distance.

[2.] Perception Test Record. A perception test-form was devised for this experiment, that was particularly related to the job classification. This test was given to the entire training group before the training, immediately following the training, and three months after the conclusion of the training. This test was constructed to involve the same skills the operator's task calls for, and to approximate the job situation as nearly as possible. Thus any improvement on the tested ability could be inferred to apply directly to the job ability.

Equipment Used In Training: The Keystone tachistoscope was the instrument used in the training. Since the operator's work is with directories, many slides were specially prepared that were derived from this source. Standard slides of nouns, digits, phrases, and figures were also used.

Method: The training program was started on February 14, 1955. Eight classes were formed with seven or eight subjects in each class. The limited numbers in each group afforded opportunity for observation of individual progress as well as personal instruction. It also allowed the classes to be re-arranged during the training period to be more homogenous as to achievement levels. At the same time the groups were large enough to maintain an atmosphere of friendly competition as a source of stimulus to achievement.

The classes were held in the morning to eliminate the fatigue that might be encountered later in the day. Each group was given one half hour of the training daily, Monday through Friday. Training was concluded on March 25, 1955, thus giving a total of fifteen hours of perception training to each subject.

During nearly every training session a five minute lecture was given on the principles underlying the training and relevant subjects as: explanation of the tachistoscope and its uses; span of recognition; speed of recognition; good reading and working posture habits; laws of learning; eye movements and fixations and the elimination of regressions; application of training to the job situation, and reduction of fatique by improved visual skills.

The first week of training included the perceptual span development series; nouns, phrases, and sentences. Beginning in the second week,

special slides produced from telephone numbers, prefixes, addresses, and names taken directly from the telephone directories were used. For variation and training in general perceptive abilities and memory, slides of forms, figures and faces were introduced.

Training was started at a span of three digits or one word. The span of recognition was trained up to seven digits or three word phrases and sentences. The special slides were prepared for a variable number of fixations at each exposure. For instance, some slides that included an entire address, or a selection from two addresses were presented at 1/10 to 1/5 second. Some slides were made to have the subjects select the correct listing fom an exposed column of five similar names or addresses, which varied from each other in only one or two letters, at one second.

The difficulty of training was kept at a point were the scores attained were between fifty and ninety per cent, in order that all the subjects would maintain an interested and positive attitude.

On the first day of training the timed perception test was presented. This test was repeated on the last day of training also. The same form was used since the test material was such that presented again after a six weeks' interval there would be an insignificant amount of recall. The test was presented and referred to as an "exercise" to eliminate any feeling of pressure.

A questionnaire was filled out by the subjects immediately following the training, and again three months later, to determine their reaction to the course, and how they felt they had benefitted and to what extent.

RESULTS

The ability to note details of listings and numbers accurately and rapidly as measured by the perception test-form, increased an average of 36 per cent for the group. The average number of test items completed accurately on the first test was 21.28, and on the second test was 28.98, giving an average gain of 7.7 items. The degree of accuracy went up an average of 1.25%. From the training records it did not seem to matter at what achievement level the subject started, she made approximately the same gain in number of test items, thus, making the lower beginners averaging a larger gain percentage-wise.

Three months following the training there was little loss of ability. The training program was based on establishing good habits of perception. Once these habits are established they should remain, or even improve with practice over a period of time. Re-testing the remaining 37 trained subjects three months after the conclusion of

training seems to bear this out. The average gain in number of correct items was 9.03, or an average improvement of 42% over the average before training. This as against a 36% improvement shown at the very conclusion of training. The per cent of accuracy also increased an average of 3.58%.

From the data taken at the three month follow-up the findings indicate a tendency for the individual improvements to level out after a time interval, so that those showing only a small gain at the conclusion of training periods continued to improve after training ended, and those showing an average or high gain remained relatively stable. The habits of good perception, once established, seem to continue to build on themselves. Only 11 of the remaining 37 people fell below their original gain, while 26 evidenced a continuing growth in ability.

The tachistoscopic training scores were kept for each subject and averaged weekly, and the gains from the second to the last week determined. These gains on the actual training were correlated with the gain on perceptive ability measured by the perception tests. The coefficient of correlation was .709, indicating a marked relationship between development with the tachistoscope, and perceptive abilities on printed material of the sort concerned in this job classification.

Since the number of operators (excluding supervisors) in the trained group, constituted only 46½ % of the total operating force at the time of the training, and only 33% at the time of the three month follow-up, it is impossible to determine with any exactness to what extent the training has improved operating officiency as to entire board loads, errors and irregularities. In order to have determined this, a study of the operating efficiency of each girl would have had to be done. The nature of this data made such a study un-obtainable. However, this office in terms of accuracy, (disregarding the slow answers) did give better service in the three month period following training. Computing the indices, after omitting observed slow answers, for the three months following the training (April, May and June) were 99.3, 94.4, and 99.6.

In order to determine what effect the length of service has on the results obtained, or at what level of seniority the training is best applied, the data was grouped by seniority of the operators. The supervisors, regardless of the length of service, were put into a separate group.

Group I	over 5 years of service	10 subjects
Group II	1½ to 5 years of service	9 subjects
Group III	1 to 1½ years of service	9 subjects
Group IV	½ to one year of service	8 subjects
Group V	under ½ year of service	11 subjects
Group S	supervisors	7 subjects

The range of averages for the groups was 19.5 to 23.3 items correct on the first test, and 26.5 to 31.1 on the second test, and 27.0 to 32.7 on the third test. Here the average scores on perception tests for different seniority levels showed that the gains for the different groups did not vary significantly. There does not seem to be any trend to greater or less improvement with training according to length of service. The training can probably then be given as effectively to one group of operators as another as regards this factor.

A general increase in accuracy following the training continued to develop after the conclusion of the training period. Data recorded on the per cent of decrease in errors showed that the percentage of inaccurately completed items began to decrease with training; and for a period after training the accuracy continued to improve. Errors were reduced an average of 1.25% by the 54 trained subjects at the conclusion of training; and for the remaining 37 subjects at the 3 month check-up errors further decreased by 3.58%.

The facility to supply detailed listings increased over one-third (36% and 42%) with an associated decrease in per cent of errors of 1.25% and 3.58%.

The tabulation of the answers to the questionnaire presented to the subjects indicated a definite decrease in fatigue and tension on the job, and a feeling of having been benefitted a great deal by the training program. At the conclusion of training 58% of the subjects felt a definite reduction in fatigue on the job, and 83% felt that the training had made their work more accurate.

Questioned again after the three month time interval concerning fatigue and accuracy, the operators seemed even more certain of having been benefitted. Of the remaining 37 subjects, 76% felt that the job was less fatiguing than prior to training, and that they were performing under less tension than before. Eighty-one per cent felt more adequate on the job and that their accuracy had improved. Many of the subjects were exceptionally enthusiastic about how much the training had helped them.

CONCLUSIONS AND SUMMARY

From the results of the project the following conclusions can be drawn:

1. The ability to note details in listings and numbers accurately and rapidly increased significantly with training.
2. This increased ability remained after a three-month time interval.
3. There was a definite correlation between the gains evidenced

in the training and the gains in perceptive ability on printed listings.

4. The seniority of the subjects seemed not to affect the amount of gain in perceptive ability with training.
5. The span of recognition for the specific job requirements may be significantly increased.
6. Slides designed for a specific purpose stimulate interest and allow for more direct transfer of learning from the training to the job situation.
7. Visual and perceptual training can be specifically designed for various job situations.
8. The training reduced the operators' feeling of fatigue and tension on the job.
9. The subjects reported a feeling of ability to do better work and an increased interest in their job performance.
10. Subjectively, less eye strain was reported as a result of the training.

In conclusion, the program was successful from two standpoints:

First, the training developed an increased ability in skills required on the job, providing the basis for better job performance and higher standards of work.

Secondly, intangible benefits such as: reduced fatigue, less tension and eye-strain, and the establishment of a feeling of being more adequate, resulted in more relaxed, less irritable individuals, seemingly able to perform more competently.

ANNOUNCEMENT

WASHINGTON FORUM ON READING DISORDERS

The District of Columbia Optometric Association will hold a forum on Vision and School Achievement, for teachers and optometrists in Washington on November 5 - 6, at the McKinley High School. Dr. Helen M. Robinson, director of the Reading Clinic, University of Chicago; Dr. Nathan Robbins, director of Visual Analysis at the Buffalo Institute of Vision and Reading Training; Father Albert F. Grau, director of the Georgetown University Reading Clinic and Dr. Frances L. Ilg, director of the Gesell Institute of Child Development, will be the speakers. Dr. A. W. Francke, Washington, will preside.

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Publication and Academy Office: 1502 Foshay Tower, 821 Marquette Ave.
Minneapolis 2, Minnesota

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THE GENERAL PROGRAM — AMERICAN ACADEMY OF OPTOMETRY

The 35th annual meeting of the American Academy of Optometry will be held in Chicago, Illinois, at the Drake Hotel, December 10-13, 1955.

The Papers and Program Committee, Dr. J. Donald Kratz, chairman, has released the first list of speakers and their subjects who will be heard on the General Program during the four-day session. A few additional papers are yet to be added to this list.

In its present form, the list is most impressive. The speakers are all well known in optometric education and as optometrists who have done much to advance the art and science of optometry. These speakers and their papers will make this annual Academy convention the out-

standing educational event of the year. The speakers and their subjects follow:

Merrill J. Allen, O.D., Ph.D., Division of Optometry, Indiana University, Bloomington, Indiana. *The Speed of Accommodation as Influenced by Age.*

Robert E. Bannon, O.D., D.O.S., Bureau of Visual Science, American Optical Company, Southbridge, Massachusetts, and Harold M. Fisher, O.D., New York City. *Physiological Aspects of Multifocal Corrections.* Lecture in two parts.

C. S. Bridgeman, O.D., Ph.D., Bureau of Industrial Psychology, University of Wisconsin, Madison, Wisconsin. *The Optometrist and Psychological Factors in Visual Work.*

Darrell B. Carter, O.D., College of Optometry, University of Houston, Houston, Texas. *Changes in Fixation Disparity and Heterophoria During and After Wearing of Prism.*

John Davis, A.B., and Gilbert Coltar, M.S., American Optical Company, Southbridge, Massachusetts. *An Approach to the Problem of a Corrective Curve Achromatic Cataract Lens.*

Margaret D. Dowaliby, O.D., Los Angeles College of Optometry, Los Angeles, California. *Psychological Problems Involved in Frame and Lens Selection for Children.*

Rudolph Ehrenberg, O.D., D.O.S., Granite Falls, Minnesota. *A Review of Current Near-Point Test Charts.*

Glenn A. Fry, O.D., Ph.D., School of Optometry, The Ohio State University, Columbus, Ohio. *Veiling Brightness and Retinal Interaction.*

Robert Graham, B.Sc., O.D., Pasadena, California. *New Resources in Ophthalmic Lenses.*

Lt. Phillip R. Haynes, Optometry Officer, U. S. Army Hospital, Ft. Jackson, S. Car., *A Quantitative Investigation of the Marcus Gunn Phenomenon.*

Frederick W. Hebbard, O.D., School of Optometry, University of California, Berkeley, California. *Observations Concerning Foveal Fixation Disparity: Subjective and Objective Determinations.*

Fred W. Jobe, D.O.S., director of Ophthalmic Research and Development, Bausch & Lomb Optical Co., Rochester. *Further Studies on the ACA Ratio as Measured with the Orthorater.*

Carel C. Koch, O.D., D.O.S., Minneapolis, Minnesota. *Minor Suggestions to Improve Refractive Care.*

Hollis M. Leverett, Ph.D., Research Department, American Optical Company, Southbridge, Massachusetts. *An Analysis of Referrals Based on School Vision Screening Test.*

David M. Michaels, O.D., M.Sc., Illinois College of Optometry, Chicago, Illinois. *Differential Diagnosis in Optometric Practice.*

John C. Neill, O.D., Pennsylvania State College of Optometry, Philadelphia, Pennsylvania. *Graduate Training for Contact Lens Practice.*

John Oliver, Ph.D., and A. R. Lauer, Ph.D., Iowa State College, Ames, Iowa. *The Relationship Between Distance Judgment, Speed Estimation, and Certain Visual Anomalies as Measured by the Sight-Screener.*

Henry B. Peters, O.D., School of Optometry, University of California, Berkeley, California. *California Experiments with Prepaid Vision Care.*

Henry B. Peters, O.D., School of Optometry, University of California, Berkeley, California. *The Orinda Vision Study—A Preliminary Report.*

Jack Prince, F.B.O.A., (Hons). Department of Ophthalmology, Medical School, and Glenn A. Fry, O.D., Ph.D., School of Optometry, The Ohio State University, Columbus, Ohio. *The Effect of Refractive Errors on Visual Acuity.*

Alfred Rosenbloom, O.D., Illinois College of Optometry, Chicago, Illinois. *Further Observations on the Correction of Unilateral Aphakia with Contact Lenses.*

Vernon I. Ryan, O.D., Pennsylvania State College of Optometry, Philadelphia, Pennsylvania. *Study of Visual Survey Tests.* A two-part lecture.

Arthur Shlaifer, O.D., Ph.D., Pennsylvania State College of Optometry, Philadelphia, Pennsylvania. *The Relationship of Blurring to Color Recognition.*

Frederick Sinn, O.D., Pennsylvania State College of Optometry. *Optics of Contact Lenses.*

Walter Tyskowski, B.Sc., M.Sc., Massachusetts College of Optometry, Boston, Massachusetts. *Evolution of the Human Eye.*

Gerald Westheimer, O.D., Ph.D., School of Optometry, The Ohio State University, Columbus, Ohio. *Measuring Bifocal Additions.*

Ralph E. Wick, O.D., Rapid City, South Dakota. *Experiences with Scleral Tonometry.*

R. J. Wixon, O.D., Shamokin, Pennsylvania. *Statistical Analysis of Hereditary Factors in Ametropia.*

Henry L. Wolfe, O.D., D.O.S., Wolfe Eye Clinic, Marshalltown, Iowa. *Scleral Tonometry and Our Experiences in Developing This Technique.*

The programs that will be given during the sessions of the five Academy Sections will be presented later.

The annual convention of the American Academy of Optometry will be in Chicago at the Drake Hotel December 10 - 13. This four-day program will immediately follow the three days of Academy Post Graduate Courses which are scheduled for December 7 - 9 at the same place. These Post Graduate Courses were outlined in some detail in the August and September issues of this publication. All Academy members and their guests are now urged to make their hotel reservations. Naturally, hotel accommodations are assigned on the first come first served basis, and the early applicants are sure of rooms in the convention hotel. Write the Drake Hotel, Lakeshore Drive and Upper Michigan Avenue, Chicago, Illinois, for your reservations today. The meeting will be an inspirational educational treat.

CAREL C. KOCH

SPECIAL REPORT

POLICY ON PRESCRIPTIONS AT THE CLINIC

SCHOOL OF OPTOMETRY, THE OHIO STATE UNIVERSITY*

Columbus, Ohio

The procedures followed by optometry in the analysis of visual difficulties are designed to study and evaluate various aspects of the eyes. As part of the examination, it is necessary to know if an eye is near or farsighted; if astigmatism is present; whether or not the two eyes are in balance with each other; how the eyes work together as a team, and so on. From such a study, oftentimes a prescription for a visual correction can be written. In the best interests of the patient this prescription should always indicate the power of the lenses necessary for adequate vision in various seeing tasks *as well as other very pertinent data.*

Many years ago, it was customary for vision specialists only to examine the eyes of a patient and write a prescription for a visual correction; the patient then had to consult an optician, i.e., a technician skilled in fabricating glasses. The optician assisted the patient in the selection of the style of eyewear and then on the basis of his knowledge

*Submitted on April 13, 1955, by Associate Professor V. J. Ellerbrock, Ph.D., for publication in the October, 1955, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

The policy on the distribution of ocular refractive prescriptions has been approved by the Clinic Staff and the above statement covers this action. [Editor, Am. J. Optom. & Arch. Am. Acad. Optom.]

and awareness of the needs of the patient determined all other pertinent data for the visual correction. Usually the type of bifocal lens, the height of the reading segment in the lens, the distance of the lenses from the eyes, the tilt of the lenses in front of the eye, the form of curvature of the surfaces in a lens, special absorptive qualities of the lenses and the centering of the lenses, were left to his discretion. Not infrequently, this procedure was not to the best interests of the patient.

More recently, vision specialists are tending to provide an integrated service for patients. With this approach, the examination and the design and fitting of eyewear are done as one unitary service. Thus the one making the examination invariably designs the eyewear, verifies the prescription in the eyewear before delivery and fits and adjusts the eyewear to the patient. Only by this method can the patient have the assurance of a correct translation of the prescription from the examination to the completed eyewear. Then, in case of difficulty or question about the visual correction, there is no doubt about the responsibility.

The filling of ophthalmic prescriptions is not controlled in any way by the federal or state governments; drugs of course are regulated in this manner under the Pure Food and Drug Act. As a consequence, one knows that a prescription filled by a pharmacist meets certain minimum standards and in this way the public welfare is safeguarded.

Unlike drug prescriptions, the only standards of quality of ophthalmic prescriptions are selfimposed by the practitioner or by those who fill them. This, then, is another reason for the necessity of the integrated service by vision specialists to best meet the needs of the public.

Optometry, as a profession has always realized that divided responsibility was not to the best interests of the patient; it has recognized the undesirability of requiring both a specialist and a technician becoming aware and familiar with the visual needs in order to design adequate eyewear. Even more important, it realized that invariably the technician neither has the access to essential data from the examination nor the training to interpret it. The only data he has available is that provided in the prescription which in most cases is not adequate for the most satisfactory design of eyewear. Optometry has appreciated the added time, inconvenience and expense to the patient when two, three and even four appointments were needed to complete the necessary services. For these reasons, optometry always has espoused the integrated approach to the eye care services.

From the foregoing discussion it now should be apparent that the use of a prescription without pertinent data on the design of eyewear routinely should not be employed for duplication and repair. Instead, all such services for eyewear, whenever possible, should be

provided by the optometrist responsible for the original examination and design.

For these reasons, the Optometry Clinics at the Ohio State University, as a rule, will not service prescriptions originating outside of the clinic.

Occasionally, a patient will ask for a copy of a prescription to be used in case of an accident or an emergency. Usually, the patient has only one pair of glasses and would be seriously incapacitated without them. Although the good motives of the patient with such a request are appreciated, it is felt that the solution to the need is shortsighted. The recommended procedure in such a case is a second pair of spectacles. Then if one pair is misplaced or broken they can rely on the spare pair; also visual discomfort, inconvenience and many more serious limitations can easily be avoided. On this basis, the Optometry Clinics do not provide copies of prescriptions to patients unless complete specifications are included.

If the patient desires a copy of the complete specifications of his eyewear including all aspects of design, it will be provided upon request. However, it will only be given to a registered optometrist and then only by personal letter.

If a copy of a prescription is wanted without specifications for design of eyewear, it will *not* be provided under any circumstances. This policy is followed due to the uncertainty of responsibility in case of difficulty with the visual correction.*

*A discussion of this report by Parkins follows in the Current Comments department.

BOOK NOTICE

THE VISUAL FIELDS. Brodie Hughes, M.B., B.S., Ch.M., F.R.C.S. Charles C. Thomas, publisher, Springfield, Illinois. 174 pages. Cloth. 1954.

Most ophthalmologists and optometrists sooner or later come to realize the very extensive part that neurology plays in many of their problems, especially when visual field changes offer diagnostic opportunities. Representatives of both groups have published numerous papers and books on field studies, written from the eye man's point of view. Professor Hughes' new book will be of considerable interest to the eye professions being written by a prominent neurosurgeon, with extensive experience in the hospitals of Birmingham (England). He has done a great deal of work with lesions of the intracranial visual pathways and has emphasized this topic somewhat more than others. In general the book may be considered as presenting three main topics:

1. Methods of perimetry. 2. The anatomical principles involved, and 3. Types of visual field defect in such pathological states as compression, vascular diseases, trauma, etc. There are many field tracings, diagrams and sketches throughout the volume. References follow each chapter and there is an adequate index as well as a table of contents.

This book is somewhat unique in being probably the only one devoted completely to visual fields from the point of view of the neurologist. Optometrists and ophthalmologists will find it a helpful source of information.

THOMAS H. EAMES, ED.M., M.D.

CURRENT COMMENTS

Terry Judith Parkins
Editorial Assistant

Optometrists will confer a favor by sending news items of general interest for this department; such as relate to new instruments, clinical techniques, education, visual health and optometric legislation and organization.

GIVING PRESCRIPTIONS IN PRIVATE PRACTICE

The staff of the clinic at the School of Optometry, The Ohio State University, has recently adopted certain policies relating to the withholding of prescriptions to patients. These policies are reviewed in this issue.[1] To some extent these policies are unique, and merit our attention as they represent a departure from customary optometric practices.

Under these new policies no prescription for glasses will be supplied direct to the patient. If the prescription is not filled by the clinic staff itself, the patient may request that the prescription and the frame measurements as well as other related case data be supplied to an optometrist of the patient's choice, but even this will not be done without a written request from the optometrist who then assumes responsibility for the case. In the past, a patient requesting his prescription was given it, and he was free to have the prescription filled elsewhere. The new policy ends this type of activity.

In a school clinic where the patient pays only a small registration fee, plus the costs of the materials supplied by the clinic, such a policy may work very well. In clinics of this sort patients expect a certain amount of regimentation. The question naturally arises as to whether

[1]Special Report. Policy on Prescriptions at the Clinic, School of Optometry, The Ohio State University. Am. J. Optom. & Arch. Am. Acad. Optom. 32.10.558-560.1955.

or not such policies could be put into effect in a private practice. We should add here that there is no recommendation on the part of the clinic staff that this be done. Nevertheless, optometrists who learn of these new policies may consider something similar for their own practices, and for this reason, a few questions should be raised as to the validity of adopting this procedure in private practice.

Suppose, for instance, a patient makes an appointment for an examination and refraction only. Is the optometrist to refuse to do this essential work solely on the grounds that he is personally unable to supervise the dispensing of the material which *may* be prescribed? Is he to refuse and thus lose the important examination and refraction fee in such a situation?

Or, suppose the optometrist has completed an examination and refraction and has written a prescription for the patient. At this point, the patient is unable to approve a selection of a frame from the doctor's samples. The patient, being unwilling to order a frame not of his choice then requests the prescription so that he can secure a frame that pleases him elsewhere. Unless the doctor gives the patient the prescription he would, quite naturally, be unable to collect the examination and refraction fee and all of the skill, effort, and time spent on the case would thus be lost.

Or, again suppose that a nearby industry requires refractions for their employees. This is a common situation. The same industry has arranged to supply prescription safety glasses to those of their workers who need them. Here employees require only examinations and refractions from the optometrist, and if necessary, of course, their prescription.

In these and other illustrations that could be added, it becomes evident that such a policy, if adopted, in private practice would, on occasion, run into difficulties.

The approved plan of the clinic may work very well for a public clinic of this sort, but it seems evident that by closely tying the professional services of the optometrist to the dispensing of materials, one is apt to produce as many basic problems as one solves.

REGISTER NOW FOR POST-GRADUATE COURSES

A large number of advance registrations already have been made for the Academy Post-Graduate Courses, scheduled for December 7-9 at the Drake Hotel in Chicago. If you have not already sent in your reservation, do so at once. We refer you to the August and September issues of this Journal for detailed reviews of these courses. Or, write to Dr. D. G. Hummel, Chairman of Administration, 418 National

City Bank Building, Cleveland, Ohio, for an eight-page program of these courses. There are forty individual courses presented in 104 hours of classroom work. These Post-Graduate Courses are presented by the Academy in answer to many requests for clinical training in these subjects.

TROUBLEMAKERS AT LARGE

Just a year ago a group of dispensing opticians started openly attacking optometry. The attack was launched because of, and around Resolution 4 as adopted by the House of Delegates of the American Optometric Association, at Seattle in June, 1954. That Resolution 4 was poorly drafted and faulty, was immediately admitted by President Brown of the A.O.A. and steps were taken to correct this at the 1955 A.O.A. Congress in Milwaukee. This was done in the summer of this year when Resolution 5 of the A.O.A. was passed, taking the place of the former Resolution 4.

Resolution 5 clearly indicates the position of optometry in relation to the field of visual care and to ophthalmology in particular. It eliminates any doubts or possible fears that ophthalmology might have as to the intentions of optometry towards ophthalmology. In spite of the adoption of this new resolution and in the face of a clear-cut statement sent to all ophthalmologists by the A.O.A. outlining all of the facts of the matter this small militant group of dispensers has throughout the year continued to engage in an unprincipled attack upon optometry. In their letters and printed material they infer that optometry is planning, not only to invade the ophthalmological field but to take over this field.

This inflammatory material—distributed widely by these dispensing opticians had an upsetting effect upon many ophthalmologists who adopted certain retalitory resolutions at their meeting in Atlantic City in June of this year. Not content with these anti-optometric resolutions, the dispensers are now pressing ophthalmology to get their further assistance in an effort to organize a campaign of abuse against optometrists in the effort to direct more patients into offices of ophthalmologists and ultimately into their own shops for frames and lenses.

During this year optometry has been quite passive, assuming that the matter would quiet down in time, as no actual harm had been done by Resolution 4. We believe the matter would have been dropped if ophthalmology had been left to themselves, however, we are now advised that these dispensing opticians are planning to continue their attacks upon optometry. Attempts will be made to create the view-

point among the public that all examining and refracting is the prerogative of medicine and that optometrists are interlopers in this field, despite the historic untruth of this statement, which untruth is as well known to these dispensers as it is to ophthalmologists themselves.

This is a situation which merits watching on the part of optometry and is one which, if carried far enough, may produce some very unpleasant reactions for all concerned, including those who so freely twist the truth. Optometry is a sleeping giant that can quickly become aroused and united in a disturbance of this sort.

PUBLICATION CHANGES

J. Edward Tufft, Los Angeles, editor for the past 13 years of the OPTOMETRIC WORLD has retired, and his many friends in optometry wish him many pleasant years to come on his farm in North Dakota.

The editorial offices of the OPTICAL JOURNAL AND REVIEW OF OPTOMETRY have been moved from New York City to Philadelphia. Maurice E. Cox, editor, and John F. McCarthy, associate editor, may now be reached at the new editorial office, care the Chilton Company, Chestnut at 56th St., Philadelphia 39, Penna.

CAMPUS NEWS

The College of Optometry, University of Houston, has announced that beginning with the entering class of 1956 the requirements for the degree Doctor of Optometry will be increased from five to six years. The first five years will be essentially the same as the present program. Th sixth year will consist largely of clinical training and approved electives in related fields such as child development, industrial consulting, reading, orthoptics and visual training, or contact lens fitting.

The Board of Trustees of the Los Angeles College of Optometry has announced the appointment of Dr. Vierling Kersey as president and director of administration of the College effective at once. Dr. Kersey served as superintendent of the Los Angeles City School System from 1937 to 1948 and as director of the Valley Junior College from 1948 until 1955.

Academy members and guests attending the 35th annual convention of the American Academy of Optometry at Chicago in December will be taken in motor coaches to the campus of Illinois College of Optometry on Sunday, December 11, for a tour of the buildings, a short program and a luncheon on the Illinois Tech campus.

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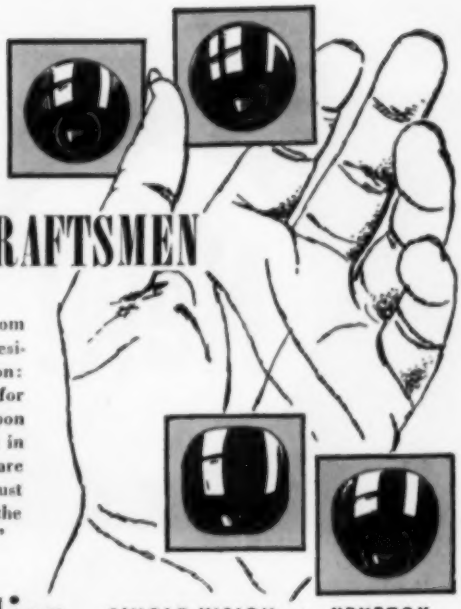

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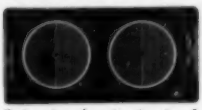

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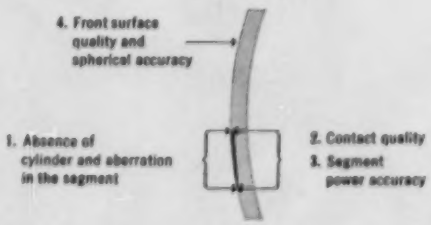
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